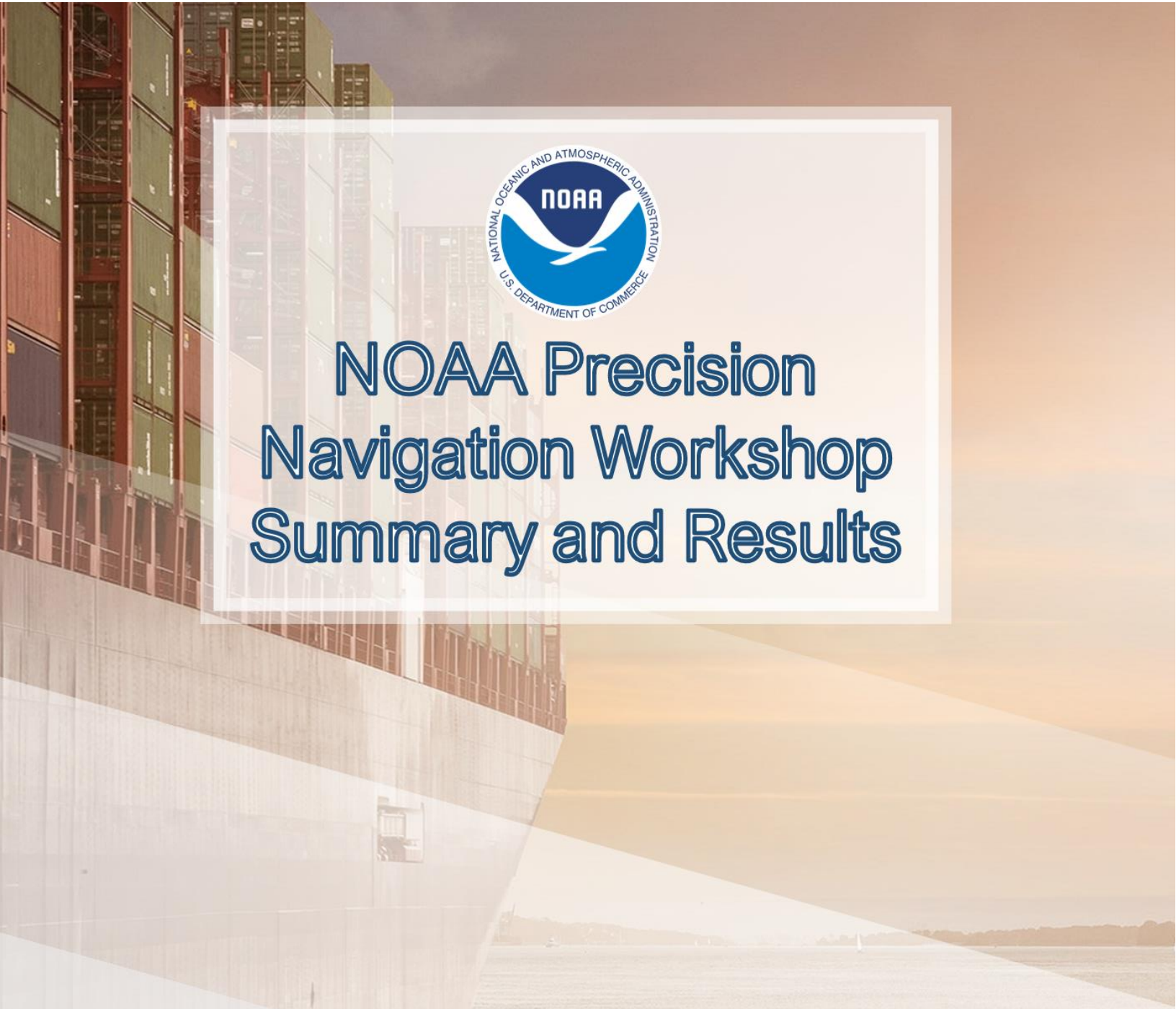

NOAA Precision Navigation Workshop Summary and Results

Center for Coastal
and Ocean Mapping
/Joint Hydrographic Center
University of New Hampshire
August 13-14, 2019

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Executive Summary

Workshop Overview

NOAA is undertaking a cross-agency P*recision Navigation* project that brings together private-sector innovation and NOAA data streams to foster safer navigation in our nation's largest and busiest seaports. Precision navigation is about helping mariners make increasingly complex decisions as ever-larger ships make their way through congested U.S. ports while dealing with changing ocean and weather conditions. NOAA aims to involve its stakeholder communities from the very beginning in the planning and development of a dissemination system to provide easy access to NOAA's marine navigation datasets to ensure maximum benefit to users. It was in this spirit that NOAA held the *NOAA Precision Navigation Workshop* August 13-14th, 2019, at the University of New Hampshire's Center for Coastal and Ocean Mapping/Joint Hydrographic Center. The goals of the workshop were to:

Provide detailed information about Precision Navigation to industry users (PPU, ECDIS, UKC companies), so that they leave with a clear idea of what Precision Navigation is and where it is going.	Provide NOAA with a clear understanding of the technical requirements of participating companies and get feedback from the companies which ingest our data streams.	Strengthen NOAA and community relationships and lay the groundwork for further engagement and development over the years to come.

Workshop attendees included NOAA representatives across multiple Line Offices, other federal agencies, private industry, and academia. The workshop was structured such that the afternoon on August 13th was focused on providing attendees with a better understanding of Precision Navigation overall. August 14th was focused on providing additional detail into the development and future of Precision Navigation, and to breaking out into small groups to answer questions, provide feedback to NOAA, and engage in plenary discussion.

The workshop's presentations, panels, and discussions covered a wide range of topics including:

- A vision for the future of digital navigation
- The S100 product suite
- NOAA data provision
- Non-Real-Time Precision Navigation Products 9S-102 Gridded Bathymetry and S-57/S-101 High-Definition Charts)
- Real-Time Precision Navigation Products (S-111/S-104 Surface Currents/Water Levels and S-41X Marine Weather)
- Precision Navigation product dissemination
- Future NOAA-partner engagement

Executive Summary

Precision Navigation

Overview

Precision Navigation will integrate marine navigation related datasets from different NOAA data streams into a single site where the datasets will be easily discoverable, accessible and machine readable. This will include NOAA datasets encoded into S-100 data formats. The datasets will be available to users including under keel clearance software companies, manufacturers of portable pilot units and electronic chart systems. By making all integrated data readily available, NOAA's partners in industry and academia will be able to develop new and improved products, tools, and services to deliver greater value to mariners. As the international community develops and approves additional S-100 formats, NOAA will encode additional marine-related data into these new S-100 formats.

Another component of Precision Navigation will be port specific projects. In order to provide assurances to vessels that they will not run aground, the Port of Long Beach pilot project was carried out. It involved the expansion of the physical observing infrastructure at the port, including forecasts for wave and swell conditions from the NWS, water level data from the NOS, wave buoy data from the U.S. Integrated Ocean Observing System, shoreline data from the NGS, and high resolution bathymetry from the NOS.

This was a collaborative effort across NOAA and with partners, and it is the aim of the Precision Navigation Program to bring this success to other key ports, beginning with New York/New Jersey, the Lower Mississippi.

Dissemination System

The system's single portal for integrated real-time observations and data will be based broadly on the successful implementation of NOAA's nowCOAST. It will also be cloud based to meet surges in demand from extreme weather, reduce overall maintenance costs, and more easily ingest data from other sources. A prototype of the dissemination system will be available on the loud in FY20. A more detailed schedule of projected program milestones may be found in *Attachment 1_Precision Navigation Overview* and *Attachment 6_NOAA Precision Navigation Dissemination System*.

Workshop Highlights

The following workshop highlights have been pulled from the full detailed accounting of results found in the report *NOAA Precision Navigation Workshop: Summary and Results (August 13-14, 2019).*

Integrating a Wide Range of Data Streams

NOAA currently provides a wide range of data streams including the real-time marine weather observations from a variety of platforms (buoys, C-MAN stations, PORTS stations/gages), marine weather forecasts, forecast guidance from oceanographic forecast models, ENCs and more. Given the broad range of data needs articulated by the collective breakout groups, there is great need and advantage in consolidating data within a single easily discoverable and accessible site.

Accounting for Differences in User Requirements

The Precision Navigation Dissemination System needs to keep in mind that different users have different requirements for data, information, bandwidth, resolution, and unique location-based requirements. Precision Navigation will need to provide solutions to each user profile and location (i.e. distance from shore) to ensure information is conveyed quickly and can be accessed easily with varying levels of bandwidth and resolution needs. It will also have to account for the dynamic needs of users, for example that marine weather forecasts and ocean model forecast guidance are most useful when planning, but point near-real-time observations become more important as ships come into port.

Incorporating and Understanding Uncertainty

Understanding data uncertainty and striving for data consistency is critically important to the success of Precision Navigation. Users need to understand how data decays over time, the inconsistencies between different products, scales, and data sources – all in a highly dynamic and ever-changing environment, necessitating quality metadata.

Obstacles and Challenges to Utilizing Real-Time Products

The greatest obstacles and challenges to the utilization of real-time products, in order of priority, are the reliability and quality of data and observation, user-friendly visual displays and formats, appropriate update frequencies, dependable technology infrastructure, good documentation, proper training and use of data, and appropriate cyber security considerations.

Real-Time Support and Communication

The Precision Navigation dissemination site needs to run 24x7. To ensure quality, reliability, and timely issue resolution, there needs to be an avenue for two-way communication. There also needs to be methods of reporting problems and receiving alerts on a tiered basis depending on issue severity.

Data Accessibility, Discoverability, and Documentation

Data must be easily accessible, discoverable, and well documented with code examples to facilitate ease of understanding and usability. Updates to existing data needs to be well documented, and the differences communicated clearly because “newer” is not always “better” depending on the requirements of the user.

Customizable Data Displays and Visualization

Critical to meeting diverse user needs is a customizable visualization. User visualization needs vary based on location and user profile, and users must be able to customize the data and displays that they see based on their bandwidth and resolution requirements. Displays also need to be simplified overall to eliminate onscreen clutter that can become distracting, deter use, or limit effectiveness.

Next Steps and Agreements

- The Precision Navigation Workshop will be held again on an annual basis.
- Future Precision Navigation engagement will involve broader engagement with federal partners outside of NOAA, and more industry partners (particularly pilots).
- NOAA will continue to send out updates and information as the Program progresses.
  NOAA seeks volunteers for testbeds and beta testers. Interested organizations should contact Captain Liz Kretovic (Elizabeth.Kretovic@noaa.gov) or John Kelley (John.Kelley@noaa.gov).

Opening Remarks

Captain Liz Kretovic, Deputy Hydrographer, Office of Coast Survey, NOAA

Captain Liz Kretovic, Deputy Hydrographer at NOAA's Office of Coast Survey, opened the workshop with some words of welcome and appreciation for all attendees making the trip to Durham, New Hampshire, for the occasion. Captain Kretovic explained that it was the aim of the workshop to impart a better understanding of Precision Navigation, where it is going, and what NOAA hopes it achieves. She pointed out that this is earlier in the development process than NOAA often engages directly with stakeholders and community members, but that all involved believed it was critical to get outside perspectives and feedback as early as possible to steer development and ensure success. She added that everyone would have time to engage in groups for more in depth discussion, and that it was her hope that the discussions held over the course of the workshop would only be the beginning of continued collaboration and engagement.

NOAA Captain (Retired) Andy Armstrong, Co-Director, Joint Hydrographic Center

Retired Captain Andy Armstrong, Co-Director of the Joint Hydrographic Center, then welcomed everyone to the facility. He highlighted some of the facility's most impressive features including a wave pool and dive pool for testing equipment and running experiments, a visualization lab, and a telepresence room to connect with ship and submersible missions in real-time. Tours would be provided later in the afternoon to allow all participants to see and experience the cutting-edge work being performed at the Center.

Introductions and Icebreakers

Introductions

In way of introduction, attendees were asked to each share their name and organization. Additional introductions and informal conversations were held throughout regularly scheduled breaks, at a group dinner Tuesday evening, and during small breakout groups on the second day. The complete list of participants, their organizations, and contact information for follow up engagement may be found in *Appendix C: Workshop Attendees and Contact Information* on page 53.

Precision Navigation Word Cloud

As an icebreaker and means to dive into the topic of Precision Navigation, attendees were asked to contribute to a word cloud by answering the following question:

"*Based on your understanding today, what one word best describes what you hope Precision Navigation will deliver for you and your community?"*

The results indicated that there was a broad and diverse understanding of what Precision Navigation will provide. There was very little overlap among the 31 responses, although "safety" was mentioned three times and "integration" twice. It was clear that the afternoon's presentations would need to begin to develop a clearer vision and shared understanding.

Precision Navigation Program Overview

As initial context and background, Captain Liz Kretovic, Deputy Hydrographer, Office of Coast Survey, NOAA, and John Kelley, Coastal Marine Modeling Branch, Coast Survey Development Laboratory, NOAA, provided a Precision Navigation Program Overview. This presentation may be found in its entirety in *Attachment 1_Precision Navigation Overview*.

Brief summary notes of the presentation may be found below. These notes should be considered a compliment to the presentation, not a substitute to the full detail and breadth of information found in the slides. Summary notes from the Q&A session are also provided.

Presentation Summary Notes

What is Precision Navigation?

Captain Liz Kretovic provided an overview of the Precision Navigation Program. Addressing the results of the word cloud and overarching question “what is Precision Navigation?”

Kretovic explained that Precision Navigation will integrate NOAA data streams and validated partner data into a single site that is machine to machine readable, and easily accessible and discoverable. Data will be readily available in a single website with a back-end NOAA API to facilitate the transfer of data information to users – including under keel clearance, portable pilot units, and fleet operations support. By making all integrated data readily available, NOAA’s partners in industry and academia will be able to develop new and improved products, tools, and services to deliver greater value to mariners. Precision Navigation will also encompass the S-100 Suite, and high-resolution data. As the international community moves to the S-100 formats, NOAA will lead and guide the transition.

Another component of Precision Navigation will be port specific projects. Even one-degree of pitch in a tanker can cause an increase of 11 feet in draft. In order to provide assurances to vessels that they will not run aground, a Port of Long Beach pilot project was completed which included a full resolution multibeam project to measure swell and develop a model that enables vessels to safely increase their draft and efficiency. This was a collaborative effort across NOAA and with partners, and it is the aim of the Precision Navigation Program to bring this success to other key ports, beginning with New York/New Jersey, the Lower Mississippi.

Building a NOAA Precision Navigation Dissemination System

John Kelley then expanded upon the Precision Navigation Dissemination System, providing a timeline of key annual milestones through FY24 and beyond. He stressed the importance of getting industry involvement early and continuously in the development process, and emphasized the value of the feedback that would be offered during this workshop and future engagements. Kelley explained that as the Dissemination Manager and Project Manager of nowCOAST, he would be bringing those experiences, successes, and lessons learned to this new Precision Navigation Program. Like nowCOAST, the Precision Navigation Program will be a single portal for integrated real-time observations and data.

Kelley acknowledged the challenge of providing data to users with different requirements (e.g. mariners with limited access and bandwidth, software developers, and academics). The aim of Precision Navigation will be to enable users to pull data from a single location based on their desired specifications and needs, and to display data and information in a format and visualization that is easier to read and understand. NOAA wants people to easily find, discover, and access information, and to see what is new, and when new data are available.

The Program will also built in the cloud. This will make it easier to maintain, to scale to meet surges in demands (e.g. from extreme weather), and to reduce overall maintenance costs. This will also make it easier to ingest data from other sources, and to provide information and data access to the general public. A prototype dissemination system on the cloud will be available in FY20.

In FY21 NOAA aims to disseminate additional S-100 Production Suite formats such as S-101 ENC, S-102 bathymetry, S-111 water currents, S-104 water levels, and S-412 weather overlays. Other additions include high-definition charts for priority ports, and a prototype in the style of nowCOAST on the cloud site to provide NOAA datasets via a larger variety of Web mapping services.

Moving beyond FY21, key Program milestones include the dissemination of additional products from the S-100 Product Suite as specifications and formats are approved & released and datasets encoded by NOAA (e.g. S-413 weather and wave conditions). By FY22/23 the aim is to have the Precision Navigation Dissemination System operational 24x7.

Other considerations in the outyears include possibly disseminating additional datasets from the S-100 Product Suite in coordination with other federal agencies such as USACE; disseminating AIS supplemental binary messages of weather and oceanographic observations from NDBC, NWLON, PORTS®, IOOS, and ASOS observing platforms, if USCG moves forward to provide capability to transmit; and, possibly expanding the Precision Navigation Dissemination Web Site to include information about marine navigation available from other federal agencies (e.g. migrate to marinenavigation.gov).

Presentation Questions and Answers

Q: You mentioned 24x7 operations, can you expand upon that?

A: That means that you have a reliable service that is up 99% of the time. When there are problems, we will likely have different tiers of response depending on urgency and severity of the issue. For example, the first tier may be active NOAA monitoring of the situation; the second tier issues are identified, triaged, and then sent to the appropriate group for resolution; and third tier response, “on call” personnel who can be contacted with a range of issues.

Q: One of the outcomes of the workshop should be agreement to perform/follow-up on a case study with the port of Rotterdam. Pilots there were receiving daily updates (PNCs) and getting real-time weather and metrological updates. There are some technical papers available for review to interested parties. We can work with NOAA to look at what has been learned since then.

A: A solution at one port will not necessarily work for all, for example applying our learning and process at the Port of Long Beach is not a one-to-one map to others. What NOAA really wants to do is make the data available for access to all of industry so that people like yourselves and others can create the specific products and solutions that work best for the individual customers. As government we want to make our data more easily available for your use, and to let you be the product innovators for the end users. Nevertheless, Rotterdam is a good example of using HD charts and other products, and it is always good to see what else is out there and available. Public private partnerships are also a great way to go.

Q: In terms of cloud computing, will there be multiple servers for places of high density?

A: Yes, we are able to shift between sites and scale at either. That allows us to shift if there is a risk of outage. We need to be able to develop, test, and implement as we develop this Program. Things change even in the NWS with all their product lines, and we cannot always respond quick enough. It is absolutely critical that we are able to deliver to customers in a reliable, 24x7 capacity. If we do not, people will not use it – it's that simple.

S-100 and NOAA's Precision Navigation Services

As further context and background, Julia Powell, Deputy Division Chief, Coast Survey Development Lab, and IHO S-100 Working Group Chair, shared a presentation on S-100 and NOAA's Precision Navigation Services. This presentation may be found in its entirety in *Attachment 2_S-100 and NOAA's Precision Navigation Services*.

Brief summary notes of the presentation may be found below. These notes should be considered a compliment to the presentation, not a substitute to the full detail and breadth of information found in the slides. Summary notes from the Q&A session are also provided.

Presentation Summary Notes

Powell shared with attendees what S-100 is, where it is going with the international community, and how it applies to Precision Navigation. It is a broad international partnership with many players, a data framework for developing the next generation of navigational charting, and also standardizing all data for product consistency, machine reading, and help with decision-making.

A large component of global consistency and the ability to use machine readable formats comes down to data discoverability and access. We want to lead the way in developing a system with easy retrieval. In this way we are all using the same shared standards and understanding when conveying information to mariners. In terms of displaying to mariners, there are two types of portrayal, LUA and XSLT, and navigation systems must use both.

With respect to S-100 discovery metadata, the key thing is that this is implemented via xml exchange catalogues. Currently NOAA has the same system built for ENCs, so if you already use that system your scripts can automatically gather this S-100 data and can further be customized to pull down the specific data based on your criteria. NOAA is now trying to do this with a broader set of data using Precision Navigation to build a reference implementation. The entire suite of S-100 products will be available under this umbrella. NOAA will not encrypt its data so as to make repackaging and customer engagement by resellers as easy as possible, however it will include an identification code to demonstrate that the data were derived from NOAA.

One thing IHO is looking at is harmonizing graphical presentations for data products. The goal is to have layers that allow each to be seen when and where it is needed in an integrated, logical way. If there is too much information or the display becomes too cluttered, safe and efficient vessel operations can be hindered; it is important to collaborate with the community to determine how best to visualize this data particularly "at the front of the bridge."

S-102 high resolution for bathymetric data on navigation systems is slated for release in late 2019. There is a Linux version currently available, and Windows version to follow in the next few months. Two test beds (US Navy and Korea respectively) are also facilitating timely development, with final work including texturing and layering for optimal display.

Also, in development are S-219 go/no-go areas with standardized outputs which are anticipated late in 2019, and S-104 water levels which the IHO is aiming to deliver as a first edition late in 2020. The goal is to have an operational S-100 edition by 2022, although this is admittedly ambitious. Data modeling and data visualization have been improving however, and it is moving in the right direction. For example, some coding solutions have been applied to reduce the length of written buoy names which can clutter a display in high traffic areas, and other improvements are being developed.

As a parting thought: standards are the building blocks of Precision Navigation. They harmonize data and improve interoperability, but they do take a long time. However, if you consider the success of F-57 with 80 participating member states producing data to the same format and standard – it can be done, and it has a big impact.

Presentation Questions and Answers

Q: How many of the attendees today are manufacturers? For those of you here who are manufacturers, the work that Julia does is the bulk of the work to get to these standards. One reason we have a lot of PPU manufacturers is that they are unregulated. We hope that there is opportunity in that arena to test how the new data streams are working. Even pre-test the drafts before they get solidified into an IHO standard. This is a definite opportunity for PPU manufacturers to take a role in how these are established. If it works for you all, it will work for the remaining 99% of maritime community.

A: The way the IHO has defined its standard, we are pretty happy and see how it works in implementation. We are trying to effect change at the S-100 level. We are determined to work alongside manufacturers. By coming to these meetings, we can see what you want and need. We want to listen to the manufacturing community about this, because it is your expertise, not ours. We are producing the data. You can partner in letting us know how to implement.

Q: It is very complex, even with the amount of time I have spent in the open source community. I like having everything come in through API. If you can use that as an abstraction layer – to abstract this very complicated information and simplify it to get it to industry, I think it would be beneficial. Is that something you are planning on doing?

A: The API is the delivery mechanism.

Q: What I see in the open source community is that you will have two products (e.g., one framework is just as capable as a second framework, but the API is abstracted in such a way that the community can access it). If you all were to spend a lot of time being able to document the API, with very robust site of documentation, we would be better able and more apt to use it – is this possible?

A: That is a very good point. We are going to have to start with a sample script. With our old way we had people trying to figure it out, and we want to simplify things.

A: API is in the current Precision Navigation project. It is in a sort of testing stage. The Precision Navigation team has been briefed on its capabilities, as has other NOAA leadership. All information is available through the API. Your suggestion is on the "wish list" at the moment. Not a lot of time is being dedicated to API unfortunately because of the broader Precision Navigation focus.

Q: There is a fine line between where we should progress regarding API. Is this something that industry can take and innovate on for dissemination? What should the government do or not do? How much of the open source community is savvy enough in this arena to move us forward?

A: Some efforts succeed precisely because of the way they were documented. Some have come out looking at how we are going to get this information out to the community.

Q: Can you give an example of where it is well done?

A: Yes, you can look around and find places like the open layers mapping framework where they have actually taken their framework and developed multiple. Now their software is gridded/outlined out so you can type in key words and get the options and parameters written in a way that you can navigate the reference very quickly. This is the make or break as to whether industry will be able to fully use this.

Additional "Live Polling" Comments and Questions

The following comments and questions were posed via "live polling" for post-meeting consideration:

- Please drop the ISO 8211 format!
- We need an S-100 presentation for novices.

NOAA Data Provision

As a final piece of context and background for the first afternoon of the workshop, a series of representatives from several key NOAA data provider organizations presented brief overviews of their respective organizations, the data they provide, what they envision for the future, and how it will tie into Precision Navigation. These presentations may be found in their entirety in *Attachment 3_Data Provider Presentations*. The presenters were:

- Peter Stone, National Ocean Service (NOS), Center for Operational Oceanographic Products and Services (COOPS)
- Neil Weston, NOS, Office of Coast Survey (OCS)
- Ben LaCour, NOS, The U.S. Integrated Ocean Observing System (IOOS)
- Hillary Fort, National Weather Service (NWS), Ocean Prediction Center (OPC)

Following these brief introductory presentations, data providers were asked to sit for a moderated panel and Q&A session. The panel was moderated by Captain Liz Kretovic, and the results are summarized below.

Moderated Panel Questions and Answers

Q: Hillary mentioned AIS. I know we have been working for at least ten years to get water level data transferred out. Peter can you speak to the status of that?

A: Yes, we have done some tests on it. Really it has fallen into a bit of a bureaucratic trap – there are limitations on what data and how much can be sent out. USCG is preventing this from happening. It ended up being an IT security issue due to data transferring across certain boundaries. It could still happen, but we have not been successful yet.

A: The loss of the El Faro pointed right at NOAA. NOAA and partners set up a demonstration, first on land and then last January at sea. The proof of concept worked. The next step is to outfit 10 merchant ships with the capability to transmit weather data. NWS and NTSB have a meeting to report back on the status of this. NOAA basically says the test was successful, and will then recommend that USCG proposes the language to change from "encourage" the recoding of weather observations to "required to record weather observations". We are hoping that this gives it a push to make this system used to its full potential.

Q: Are other countries already doing this with weather data?

A: Yes. The USCG has not established the infrastructure for this to happen yet though – it is a matter of budget and resources, not technical ability. It is not a bandwidth issue either, it is that mariners have to use certain required equipment. Until something new is mandated, it will be existing infrastructure.

A: I personally don't think AIS is a reliable way to send information. The check sign two-digit hexadecimal; there is no way to get that information by AIS reliably. There should be another way to send that data. You have millisecond frames and can only send so many messages per second. If two vessels are far enough away the messages can come out of two antennae as the same time, conflict, and then be received wrong (t would validate properly but be corrupted data).

A: The holdup is USCG, so until they do something to unlock AIS systems, we will not make forward progress.

Q: Regarding the national format, what data are being parsed out?

A: By national standard format we mean that for any technology we take on, we usually work towards net compliant format and create DACs. We will take data from anyone that passes our standards. At the global level we are working with WMO to come to agreement. For buoys we have a set format and working on gliders and high frequency radar.

A: Internationally we can work with you to map into the national/international formats as well.

Q: Peter, in a restrictive budget environment, what strategies does your organization implement to observations and making them available to your users?

A: We do not have the capability to make every observation in every circumstance. We have to rely on partners to bring in some of their data sets. It gets back to culture versus innovation. Our culture is that we need to make sure all observations are accurate. Now is that level of accuracy needed for real time navigation? Climate studies? We know the accurate requirements for climate studies, for example, but we don't have a good handle on the accuracy requirement for navigation. We think it is similar – especially in the Great Lakes – but we are not 100% sure. It would help us to know what the accuracy requirements of water levels and currents.

Q: Just getting our bathymetric data to 5cm accuracy at the moment of acquisition would be great, and water levels and currents are even more challenging. This is critical because people coming into locks come in with only 7 inches of clearance. The uncertainty question is a good one – what *is* the requirement?

A: You can make a lot of observations with low uncertainty, or a few with high certainty. Coverage and reliability are also important, it is not just accuracy. It depends on the user and application too. For example, the St. Lawrence River and seaway is in decimeters. It is suitable for making informed decisions and is extremely reliable.

A: Precision Navigation is not primarily built for the open sea, it is intended to be in a more constrained and focused near shore environment. On the weather end NOAA is looking more broadly, all the way to the EEZ. The Office of Coast Survey is as well, but there is still greater need closer to shore.

A: To have this precision measurement will be extremely beneficial to mariners. When you shut everything down it costs the whole economy $350M per day; the more data we have, the deeper we can get ships, the more money operators can make.

Q: How useful is it to visualize the uncertainty?

A: Very important. When the current gets strong, we have sand waves that we can see on multibeam. Then a lump builds and it is a dynamic situation.

Q: Would it help to have an overlay of estimated uncertainty, and would it impact your decision making?

A: Yes! This would help mitigate the risk of the ship owner and pilot. It would be invaluable.

Q: What about using vector tiles to transmit data, couldn't this help with bandwidth issues?

A: We understand the value and ease of transmitting vector tiles, but where we want to go is high definition, it just becomes a bandwidth question.

A: Yes, but if you take vector data and combine it with high definition, then combine it with vector data, you can request one small block at a time as needed in vector tile form.

A: When we begin to talk about a layer that gives uncertainty data, the CATZOC should give you some providence of the quality and source of the data. Perhaps it can be improved or developed, but we should be careful not to create something that conflicts with the authorized charting.

Q: Hillary, what is expected to be gained from transition to digital weather for mariners?

A: Our main goal is to increase visibility of weather hazards at sea. We think digitizing will increase visibility and allow mariners to make better decisions. The information now available is so detailed compared to when the products were first designed. With digitization we are able to convey *so much* more. Implementation will be the next big struggle – determining how to implement across the globe with countries with different resource levels. We want polygons to be more definitive, give uncertainty, and in an integrated way with ECDIS or other systems allow you to make quick and effective decisions. What helps us is that the US government can assist with uptake across the world. Some of the other weather services across the globe cannot support the same effort to get there. For example, the surface currents are happening now because we as the US can get it done and make it available to others. The same can be said of databases and catalog files – because we have done it in a more open source way and used government funds (so there is no copyright) we can put it out there to help with the uptake beyond the US. That is a lot of the intent of what the NWS is doing.

Q: Who are the primary users of IOOS surface current data and how does the mariner community use it, and will that change with Precision Navigation?

A: One use is to help oceanographic model development and maintenance. The other is search and rescue, and the third is contaminant response (e.g. oil spill). We talked about culture eating innovation – a lot of our innovation at IOOS is through partnerships that are not limited, and we are pretty flexible and able to adapt especially in terms of IT. We have partnerships with other agencies, and the high frequency radar relationships with manufactures and others allow us to gauge interest and explore opportunities with manufacturers.

Q: What are your depth limitations with high frequency radar?

A: It is basically 2-3 antennae on the shore sending out basically at the surface level (top skim of water).
A: We are trying to get some senators and congressmen on the water in Mississippi to help fund air gap sensors and other valuable instruments. We want more precision data.

Q: Neil, would you share a little bit more about the work you are doing on the API?

A: A little background on API. It was Captain Brennan and Admiral Gallaudet who initiated this when they had to go to many different websites just to travel from A to B location. They noted it would be much better to have a platform where people can go without knowing the inner workings of NOAA. We looked at what sources of data we have at NOAA, how it is stored, and the API will disseminate the data in its native form to the end user. The goal is to see data sets that are readily available and informative to the mariner. That's the driver for developing the tool. It is fairly easy to add new data sets, we just need to know where they are on the web and make sure they are available for the public.

Topic One: Non-Real-Time Precision Navigation Products (S-102 Gridded Bathymetry, S-57/S-101 High-Definition Charts)

Captain Rick Brennan, Chief, Hydrographic Surveys Division, and Craig Winn, HD Charting Portfolio Manager, both of Office of Coast Survey, NOAA, introduced the topic of non-real-time Precision Navigation products. The topic was focused on S-102 Gridded Bathymetry and S-57/S-101 High-Definition Charts. This presentation may be found in *Attachment 4_Non-Real-Time Precision Navigation Products*.

Brief summary notes of the presentation may be found below. These notes should be considered a compliment to the presentation, not a substitute to the full detail and breadth of information found in the slides. Attendees then joined small breakout groups to brainstorm, discuss, and prioritize responses to the question, "*What obstacles and challenges do you face in utilizing our HD ENCs and gridded bathymetry?"* the results of which may be found below.

Presentation Summary Notes

National Bathymetric Source

The National Bathymetric Source (NBS) Project was conducted to assemble all of this data into a single model for the entire sea floor for the entire nation. Recompiling bathymetry has been particularly important for rescheming charts and for coming up with new scales. That is the biggest piece to derive these new developments. Mariners, ports, and pilots would request certain things and that is why we have different scales, sets, and grids. As we move forward, we need to be more methodical in our structure. As we move towards data driven workflow, we are building out these bathy models on a production branch basis and compiling into a database.

S102 is basically a chart product in gridded format. The value of that is that the data synergy will allow us to take gridded data like this and apply real-time water levels and depth. We want to drive this forward – it is a big lift and it will take a long time, but we have to start somewhere. To do that we are building out the NBS database. It is not just NOAA data – our USACE collaboration has gotten closer – and if we want good bathymetry in navigation channels we will need it in as close to real time as possible. Working with USACE to get the metadata needed in rapid turnaround time is critical. Currently we are focusing on the Mississippi River. It is the most important area right now, and with the flocculation and sediment deposits it is very challenging, but if we can do it there we can do it anywhere.

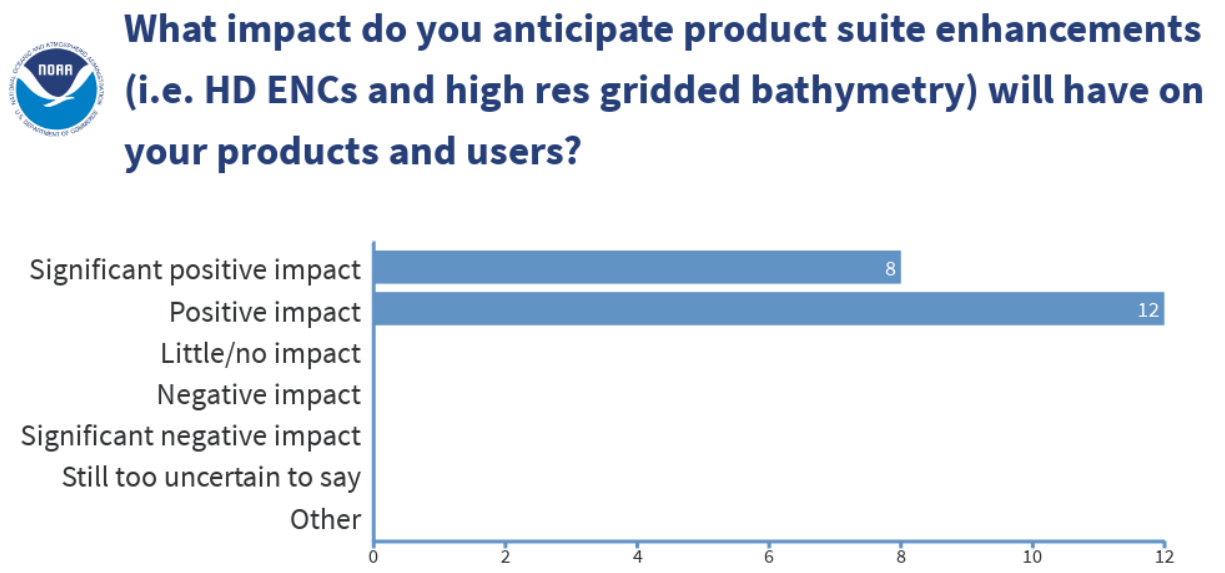
Assembling this into a data tank and then disseminating out to multiple products is the intent. We would do this through an extraction layer to convert it into V-datum, IOOS modeling, tsunami inundation, storm surge modeling, and others who have unique needs. We want to be able to extract the data out to facilitate any of these needs. When the data comes in it goes through a quality check to ensure it meets our standards, and is the ingested. As we do this we need to keep in mind that "newer" is not always "better", and that high quality data may be preferable in some cases to newer lesser quality data. We cross reference the data we ingest with that which is already on the chart and compare with historic and partner data. This will lead us to find that there will be sections of our new charts that show data gaps where our current charts do not – that is because it does not all exist digitally yet. Next we disseminate that data out to the mariner, and that's the challenging lift John Kelley is working on.

High Definition Charts

The drivers of HD Charts have been the growing use of deeper draft vessels, increasingly advanced ENC production systems, increased availability of high-quality source data, and consumer desire for data rich chart products. These HD Charts require HD ENC specifications, test area(s), source data specification, a compilation process, and sample deliverables. HD ENC specifications require charts to be built to the IHO S-57 standard, validated against IHO S-58, IHO scale band 6: 1 to 5,000, gridded to adhere to MCD re-scheme, and be an Official NOAA chart product. Initially the test area will be limited in the first phase to the Port of Long Beach and the Mississippi River.

Live Polling: Anticipated Impact from New Product Suite Enhancements

Following the presentation on non-real-time Precision Navigation products, attendees were asked *"What impact do you anticipate product suite enhancements (i.e. HD ENCs and high resolution gridded bathymetry) will have on your products and users?"* The responses indicate that the new enhancements are indeed valuable and worthy of pursuit, with 100% of responses being positive, indicating that they will have a "significant positive impact" or "positive impact".



Presentation Questions and Answers

Q: What is the difference between depth data from ENC and depth data from S-102?

A: It depends on the user. Some users need an ENC product. But a source provider or alternative user could use S-102 for their needs. But ENC is still a key product. It's still a data provider and still the same data. We are trying to automate to have both production schemes produce the same output at the same time.

A: S-101 and S-102 need to roll out at the same time. They are more integrated with each other. You can take the water level grid for instance, in the case of LA long beach with 1-meter contour intervals. If higher resolution is required, use the S-102.

A: The ENC is always the base layer because it contains all the regulated data that you need. The S-102 layer could potentially replace the bathymetry part of that data set *if* it is provided by an authorized government agency office.

Q: Is it correct that through this product we could create any dimension of data that is required/desired?

A: The data needs to be captured in a real way particularly across our customer base. If we put out a "one size fits all" for everyone we are going to have a lot of problems.

Major Messages from Breakout Groups

After compiling all breakout group responses to the question and sorting them topically, we can see several major messages which are summarized below. The complete topical sort of all responses may be found in *Appendix A: Topical Sort of All Breakout Group Responses by Question* beginning on page 29. Each individual breakout group results may be found in *Appendix B: Individual Breakout Group Results* on page 41.

The question posed to each breakout group was "*What obstacles and challenges do you face in utilizing our HD ENCs and gridded bathymetry?"*

Uncertainty and Data Consistency

Understanding data uncertainty and striving for data consistency will be critically important. Users will need to understand how data decays over time, inconsistencies between different products, scales, and data sources all in a highly dynamic and everchanging environment.

File Size, Access Speed, and Bandwidth

Users have different data, information, bandwidth, and unique location-based requirements. Precision Navigation will need to provide solutions to each user profile and location (i.e. distance from shore) to ensure information is conveyed quickly and can be accessed easily with varying levels of bandwidth and resolution needs.

Visualization Needs

Visualization needs vary based on location and user profile, and displays will need to be flexible and customizable.

Overall displays need to be simplified – too much clutter onscreen can become distracting and deter users or limit effectiveness.

Data Accessibility and Dissemination

Data must be easily discoverable and accessible, and good documentation and code examples will help make this possible.

Building the Pipeline

The industry needs to continue to build the pipeline of future users, this necessitates a culture change, training to support transition, and technology changes.

Report Out Questions and Answers

Q: Having heard the top voted responses from each breakout group, what questions do you have? What has been your reaction to what you have heard from other groups?

A: This confirms questions we had in our early process about portrayal, the delivery of data, and bandwidth sizes. We had long arguments about the size of the data set. These priorities validate the discussions we have been having. I will take this back to the international community so that we refine the areas that are of concern.

Q: What opportunities exist for industry partners to influence development?

A: For anyone in the PPU industry, there is a real opportunity now particularly from the portrayal side, because the next S-52 has not yet been sorted out. It is a contentious issue at the IHO right now, but the opportunity is there for leadership in the PPU community to show what the next round of portrayal should be and to come up with a portrayal system that does the data justice and highlights or downplays as appropriate. Updating portrayal requirements is significant and a great opportunity for industry leadership.

Q: It is a challenge in itself having the offer go out to PPUs. They wonder, "Are we the researchers? Should we be figuring out what the portrayals should be and could be? Should this be our resources, time, and talent?" It gets to be a chicken and egg thing with who will do research and who will affect the portrayal rules. What is the motivation for investing resources in doing this work? A lot of people will not volunteer if they cannot see what is in it for them.

A: NOAA funds this Center for Coastal and Ocean Mapping/NOAA-UNH Joint Hydrographic Center to support the maritime industry. The resources are here. Collaboration is the ticket to entry to getting an industrial consortium membership here. There is a significant body of experts here to help in that direction. A number of the PPU representatives are mariners themselves and are frustrated with the situation. They can help craft developments in a way that is best for them. This is a unique opportunity to influence and get it out in front and influence NOAA as we go back to the standards committee and show what the users want.

Q: We need the mariners' experience. Can the mariners send us [Brianna Sullivan, UNH Visualization Lab] a list of use case scenarios and issues that you are finding? You may not be able to dive into the issues, but if you let us know what you are encountering, we can prioritize those issues and make it a collaborative effort. We in the visualization lab love figuring out the best way to display data and we need your perspective.

Q: One portrayal does not fit everyone. If we make a lot of rules as to how to visualize data, we may restrict the ability for different users to leverage it for different needs. Will we have the flexibility we need?

A: Yes, but we [UNH] also need a few certainties where we can have them.

A: Our intention [NOAA] with portrayal is to make it more machine readable, but really for the base stuff within the regulated environment. We are not trying to standardize portrayal, because there are so many different cases where it is needed. We just want portrayal on the front of bridge system (surface current, ENT, bathymetry, etc.). Often there is a decision made to not standardize the portrayal. There are challenges with portrayal, but the standardization is from the front-end perspective. That's what we are after. Our partners in Korea have been working on modernizing the existing chart symbols and color patterns to move away from traditional library as well.

Topic Two: Real-Time Precision Navigation Products (S-111/S-104 Surface Currents/Water Levels & S-41X Marine Weather)

Dr. Neil D. Weston, Technical Director, Office of Coast Survey, NOAA, and ENS Hillary Fort, Technical Operations Coordinator, NOAA Commissioned Corps, introduced the topic of real-time Precision Navigation products. The topic was focused on S-111/S-104 Surface Currents/Water Levels and S-41X Marine Weather. This presentation may be found in *Attachment 5_Real-Time Precision Navigation Products*.

Brief summary notes of the presentation may be found below. These notes should be considered a compliment to the presentation, not a substitute to the full detail and breadth of information found in the slides. Attendees then joined small breakout groups to brainstorm, discuss, and prioritize responses to the questions:

1. *What NOAA data streams are you currently ingesting and how?*
2. *What are the most important variables to capture and visualize in real-time as you consider the future of Precision Navigation?*
3. *What obstacles and challenges do you anticipate in utilizing real-time products? For example, is there a minimum reliability/update time needed for real-time products to make a positive impact on your organization?*

Presentation Summary Notes

Surface Current Data for Precision Navigation Applications

Much of the data leveraged in Precision Navigation comes from forecast systems' complex models that run 24x7 with output every six hours. Operational Forecast System data includes water levels, wind speeds, water temperature, salinity, and currents. These are based on the main components of the Operational Forecast System: hydrodynamic model predictions, product dissemination, and quality control monitoring.

The primary goal is simplicity, and to deliver a product that is much smaller in size. Water depth is very important, and grids are regularly spaced at about 500 meters. Another critical component is surface currents and operationalizing S-111 data, with the goal to:

- Develop a service to disseminate OFS surface current data in the IHO's S-111 format
- Use in Electronic Navigation Systems (ENC)
- Design S-111 data for interoperability
- Base IHO product specifications on the S-100 Framework
- Have the IHO adopt S-111 Surface Currents Product Specification by February 13, 2019

With respect to surface currents metadata, the frequency of output is four times per day. The time resolution and duration will range from hourly out to 48 hours, with resolution to 500 meters. Examples of what this looks like, including animated displays, may be found in the *Attachment 5_Real-Time Precision Navigation Products* presentation.

S-41X: Marine Weather Overlays

The goal of the S-41X Weather Overlay is to Develop a navigation safety S-100 based product specification for weather information for use in Electronic Chart Systems (ECS) including Electronic Chart Display and Information Systems (ECDIS). The aim is to develop a global product that adheres to WMO 558 standards and NOAA-specific weather standards. There are some problems with this in terms of differences in definitions internationally (e.g. hurricane versus cyclone). We are also trying to account for S-41X Weather Overlay Requirements such as:

- Allowance for:
    - Atmospheric systems
    - Messages (warnings, watches, advisories, synopsis, forecast statements, etc.) – emphasis on polygonal warnings
    - Sea-surface conditions
    - Marine and coastal weather and wave observations
    - Vector (weather objects/polygons) and gridded formats
    - As much as practical, compliant with the Joint IMO/IHO/WMO Manual on Maritime Safety Information (MSI).
- Warning requirements, visuals and terminology shall, as much as practical, match the standardization outlined in WMO 558.
- Where possible, these product specifications should harmonize with other S-100 based product specifications.

Broadly, these requirements fall into the categories of 1) main (what is needed to build a complete product), 2) feature catalog, 3) portrayal catalog, 4) data classification and encoding guide, and 5) exchange format.

The vision and desired outcome of S-41X Weather Overlays breaks down into three main product specifications:

S-412	S-413	S-414
Wave and Weather Hazards	Wave and Weather Conditions	Wave and Weather Observations
Polygons	Features (e.g. fronts) Gridded Data	Point Based Data

The first version was released last September, and the next iteration will be released soon. We are collecting feedback and are happy to receive more from workshop participants. Moving into the future, S-41X will continue to evolve based on changes in global and technical policy, dissemination, streamlining outputs on a global level, and changes in technology.

Presentation Questions and Answers

Q: Is there enough information in the data format that we are providing that manufacturers could go from streamline to portrayal, or would additional information be needed?

A: We [UNH] are working on it now. Right now, the S-111 standard is out, but we do not have anything that reads in S-111. The streamline is not available. We are trying to have it up in LUA. The deadline is at the end of September, and we will hand off the code.

Q: NOAA/IHO made the decision to do basically two things: 1) grid data at 500 meters, and 2) hourly time zones. For this group the model runs to higher resolution. Many years ago, we got feedback that we needed more resolution in the channels. Going to 500-meter resolution is good, but do we lose that? Is that still important? And is hourly time zone acceptable? We can subsample the data down to six minutes. It is a lot of work and data storage, but is that a requirement for the community? Please consider this in responding to the breakout group questions.

Major Messages from Breakout Groups

After compiling all breakout group responses to the question and sorting them topically, we can see several major messages which are summarized below. The complete topical sort of all responses may be found in *Appendix A: Topical Sort of All Breakout Group Responses by Question* beginning on page 31. Each individual breakout group results may be found in *Appendix B: Individual Breakout Group Results* beginning on page 44.

The questions posed to each breakout group were:

1. *"What NOAA data streams are you currently ingesting and how?"*
2. *"What are the most important variables to capture and visualize in real-time as you consider the future of Precision Navigation?"*
3. *"What obstacles and challenges do you anticipate in utilizing real-time products? For example, is there a minimum reliability/update time needed for real-time products to make a positive impact on your organization?"*

Key NOAA Data Streams

There is a wide range of NOAA data streams currently being ingested, including NDFD and other forecasts, PORTS®, real-time weather and water observations, PROTIDE, ENCs and more. Given the broad range of data needs articulated by the collective breakout groups, there is great need and advantage in consolidating data within a single easily discoverable and accessible site.

Important Real-Time Capture and Visualization Variables

By frequency and vote count across all breakout groups, the most important variables to capture and visualize in real-time are depth, tide, water level, and waves. Beyond these core features, other notable variables with two or more mentions across all breakout groups are marine weather, use of robust APIs, customized portrayals, PORTS® sensors, AIS, visibility, and wind.

Obstacles and Challenges to the Utilization of Real-Time Products

In order of frequency, the greatest obstacles and challenges to the utilization of real-time products are reliability in data and observation quality and availability, a user-friendly visual display and formats, appropriate update frequencies, dependable technology infrastructure, good documentation, proper training and use of data, and appropriate cyber security considerations.

Report Out Questions and Answers

Q: I have a question of clarification on the topic of "continued open and free access" (group 3). Why is "Continued open and free access (without required authentication/security protocol)" an obstacle, challenge, or concern?

A: It comes down to security protocol. It would still be free data, but there are digital signatures. Most of the world data has to use IHO key security data, so the authentication would come from what IHO has developed and should be seamless. Data would be free for use in navigation systems, we would have a digital signature but not full encryption.

Q: That makes sense, but if it is going to a third party – maybe selling it – there could be a paywall involved and wouldn't that be troublesome?

A: Yes, most of the world buys our [NOAA] data. They pay for the service. We do not provide specific services for user needs, that is not our model.

Q: Is the authentication routine going to be commandeered by the IHO? Is there a way around that?

A: Most pilot systems, because they're trying to sell to foreign markets, already have to have IHO protection scheme built in. We are the only ones in the world who do not encrypt our data. By using IHO encryption, we lower the threshold for usage. We just "glom on" to the certification, and IHO makes the list and sends out the keys. It makes the implementation easier. We have asked IHO to split encryption and authentication.

Q: Is this encryption software publicly available?

A: We have a private key.

Q: My only concern is to ensure that our data is not being sequestered in such a way that people cannot use it for innovative means. Is this too limiting?

A: There may be two distribution points: 1) web-based navigation systems, and 2) unsigned data which would not be considered official data (the "free for all").

Q: What about specific requirements with respect to visualization? And how "real-time" does this need to be?

A: Strangely enough, "the most recent" data does not always indicate that it is still valid.

A: I am concerned about the model data being hourly. I wonder if the hourly model data passes over some of the water events (i.e. large events with high waters or strong currents). I know high resolution means more data, and it becomes a lot harder.

Q: Why not provide options as to the amount of data provided?

A: The model being run is six-minute data, but yes that is a valid suggestion – for the user to specify what level of data they want.

A: At NWS we have been dealing with this on the weather side. As model output becomes more frequent, we have had output fields that are composites over time. You can get a flavor of what is in the data. With storm surge, you can figure something out relatively quickly. Depending on the application, you may have to have more frequent outputs.

Q: Are you saying that a lower resolution time stamps is an option, while pointing out the maximum between the hourly?

A: Yes. We are working on this.

Q: There is an issue we have danced around on this one topic, and that is the difference between point observation and model prediction. Maybe it is completely apparent to the navigation community, but is it clear how each is used and how they work in conjunction with one another? That could be a big discussion on its own. Within COOPS there is a perception that the model information is not as valuable to mariners as the point gauge observation. Like everything else – that would depend.

A: A model forecast is good for planning for the future or for places you do not have observations. One should be careful in comparing the two. You always have to treat observations as "true", but now models give you so much more information in ways that observations cannot.

A: Often a point observation will tell you about a specific instant in time, but the model will give you the general idea, maybe the hour. If the meters could do some kind of averaging – if point observation could do a running average, it could be a lot more accurate.

Topic Three: Prevision Navigation Product Dissemination

John Kelley, Coastal Marine Modeling Branch, Coast Survey Development Laboratory, NOAA, and Jason Greenlaw, Precision Navigation Dissemination Team, NOAA, introduced the topic of Precision Navigation dissemination. This presentation may be found in *Attachment 6_NOAA Precision Navigation Dissemination System*.

Brief summary notes of the presentation may be found below. These notes should be considered a compliment to the presentation, not a substitute to the full detail and breadth of information found in the slides. Attendees then joined small breakout groups to brainstorm, discuss, and prioritize responses to the questions:

1. *What methods make the most sense for you to discover and access data?*
2. *What are your format requirements/restrictions to easily and reliably utilize Precision Navigation data?*
3. *How would you prefer to contact NOAA when there are problems with the data delivery and dissemination system?*

Presentation Summary Notes

Ultimately the vision is to build a dissemination system that will make it easier for ECS and PPU manufacturers and under-keel-clearance software companies to ingest/process/display NOAA's marine navigation data and information to enable precision navigation at major U.S. seaports. S-100 will be a continued effort over many years. Perhaps decades or more. The plan is to try to operationalize the site by 2023 with initial datasets available in March/April of 2020 so you can try out the system and datasets and get feedback to us. We are trying to get manufacturing and other industry representatives to provide feedback before we complete creation.

The dissemination site will create a high-reliability, centralized, cloud-based acquisition system to provide a seamless coverage of interoperable hydrographic and bathymetric information along with meteorological and oceanographic observations and forecasts for US coastal waters. The dissemination system will make the data and information available in standardized formats including the IHO S-100 framework and other standards (e.g. Web APIs such as OGC protocols), and an accompanying NOAA web site, *marinenavigation.noaa.gov* will provide information about NOAA's Precision Navigation products and how to access them.

The overall process begins with 1) acquisition, then 2) processing, 3) ingest, and finally 4) dissemination. NOAA needs feedback from workshop attendees, industry and other partners, and continued engagement to determine what is needed, what should be added, and what may need to change. The first step is to get data integrated from multiple sources in a cloud environment. Ideally between NWS and NOS there will be automated pushes so that there is no need to search deep for the data. This may not be feasible for all data sources, so there will need to be a process of uploading to cloud storage which in turn would trigger a notification for new processing.

This is an "event-based approach" – once a file arrives, the notification triggers the data processing pipeline. In theory this will be the same process of converting, aggregating, and formatting. For example, model outputs that NOS produces are fairly raw in format. It is a 3D model with sigma coordinate systems and is often difficult to use given different requirements. During the processing of model data, we take this native model grid (usually curvilinear), and grid horizontally and vertically so that it is a standard level. For surface currents data, we take in small outputs and transform them to depth below the surface.

In addition to model data, there are other data sets that NOAA produces, such as radar data from NWS. This is compressed and processed into the right format so that it can be easily integrated into other systems and disseminated. Mostly metadata, like housekeeping, is a matter of putting things in their proper place. Once in its proper location and format, it can be picked up.

The question remains: "what is needed in terms of discovery and format?" We hope to gather that information from everyone at this workshop. A lot of what we are doing already will still apply: building the back end infrastructure, and gathering requirements and usages.

Major Messages from Breakout Groups

After compiling all breakout group responses to the question and sorting them topically, we can see several major messages which are summarized below. The complete topical sort of all responses may be found in *Appendix A: Topical Sort of All Breakout Group Responses by Question* beginning on page 36. Each individual breakout group results may be found in *Appendix B: Individual Breakout Group Results* beginning on page 48.

The questions posed to each breakout group were:

1. *What methods make the most sense for you to discover and access data?*
2. *What are your format requirements/restrictions to easily and reliably utilize Precision Navigation data?*
3. *How would you prefer to contact NOAA when there are problems with the data delivery and dissemination system?*

Best Methods for Discovering and Accessing Data

The broad consensus is that there needs to be an API with metadata backbone and a single one-stop-shop site for data discovery and access. In terms of communications and notifications, the most prevalent methods are traditional mailing lists, social media, homepage messages, and online catalogs and subscriptions.

Format Requirements for Easy and Reliable Use of Precision Navigation

The main format requirement to reliable Precision Navigation utilization is that users are able to customize the data that they see based on their bandwidth and resolution requirements. Higher resolution and large file sizes can be problematic at sea, and users should be able to select parameters as they need them.

Compatible and interoperable formats are also critical, with frequently cited formatting types being JSON and XML. S-100 compliance is also a key requirement. Furthermore, if Precision Navigation is to go real-time, it will need to be highly reliable and necessitate reconfiguration to ensure success.

Preferred Methods of Reporting Problems

There is a great deal of consensus on how people would prefer to contact NOAA in the event of problems. There should be:

- A 24x7 support line for real-time assistance in the form of phone, online chat, and email.
- A highly visible contact instruction on the home page that includes simple forms for communicating and reporting problems.
- An automatic confirmation of receipt upon issue submission; people should not be left to wonder if their message was received or how/if it will be acted upon.
- Proactive announcements and notifications from NOAA when there is a known issue; this will alert users to issues and cut down on the volume of duplicate issue reporting from users.
- Automated responses (AI, machine to machine, and bots) to increase speed and efficiency.
- Tiered support based on the severity of the issue; response times and attention should be directed to top priorities before lower-level issues.

Report Out Questions and Answers

Q: This is a touchy question, but when NOAA says they are going to do something 24x7, are they guaranteeing service to the end user? I get nervous about committing NOAA to 24x7.

A: Perhaps it should be 24x7 reporting, not guarantee of immediate resolution. Resolution may take time and that needs to be defined. Issues should be acknowledged, but not necessarily fixed right away. It is about managing the expectations of the user.

Q: How will the dissemination site be organized? One thing I took away from these discussions is that a lot of people focus on comparatively trivial/recreational users. To my view the marine navigation portal should not be flashy. It should be competent, technical, and oriented to technical users of data. Requests for help should be coming from technical people who are on the expert side. In COOPS we get a lot of questions asking trivial things about their weekend fishing trip for example. We do not want that kind of users coming to us with questions and issues. We should build Marine Navigation to be useful for industry.

A: It will not be flashy due to limited resources, but we do want to serve commercial as well as recreational. I envision some people will go to three sections and then the section on PN will get very technical for advance users. There is still a need across NOAA to have a Marine Navigation website to point people to the information we have across all sections. It will take a long time, but this is still the vision.

Q: Is NOAA able to commit to 24x7 support? It is important because people are making critical decisions based on this information.

A: If we are making real-time data available, there will be an expectation that we will be responsive in responding to and resolving issues.

Q: Regarding 24x7 operations, we have been going along with the thought that eventually the Global Maritime Distress and Safety System (GMDSS) will morph into e-navigation. I do not know how long that will take. The truth is that the products are outdated. If it were to happen and where we have to be 24x7 operational, certain weather products will also have to be reliable 24x7. How will we do this? It is very challenging to support such a system and there are questions internationally that we will have figure out in the next few years.

A: Regarding the requirement for charting, I [Julia Powell] was tasked with creating a draft roadmap of how to get S-100 as part of the IMO performance standard and making sure we had everything we needed to ensure proper testing. That is the big missing piece and we are planning it out, and it will have to happen in the next 2-3 years for all this to work. The beauty is that because NOAA is moving forward on product development we can get ahead of the curve and influence where things need to go in terms of some of this stuff and fix things ahead of time. With partners and PPUs we are allowed to be more innovative before tackling the bigger pieces.

Q: Are any workshop attendees using S-100 data sets now?

A: By show of hands, there is wide use of S-100 data sets.

Q: And how is the S-100 experience so far?

A: It is very dynamic and overall good. One drawback is that the S-100 framework is very structured and sometimes requires a lot of initial generation of the catalogs so that we can get it running and test the data sets and vet out issues. The catalogs are slower to come about and so that is challenging.

A: Building of the discovery catalogs is probably the harder piece. That is why we sped up the building of the dissemination system, to be able to get catalogs out.

A: Sometimes we try to generate test data sets to try to prove or disprove what we are being given.

Q: Is there one area in next 3-6 months that the Precision Navigation team should concentrate on? More test data sets?

A: Getting the portal stream consolidated for all S-102s, and the S-100 series stuff is further down the line. If you do not have your current stuff lined up – that is where I would focus my attention.

A: The next step is to support current users. We still have trouble finding NOAA products. It takes time. Getting those APIs up and running with s100 style data would be great.

A: Our breakout group mentioned the importance of making sure the building blocks are there and ready to roll out. Potentially one of the things we should put money towards is a geo server to get the data streaming out, recognizing the geo server does a lot of what we want. There may be some additional work and if we sponsored that it might help move the whole industry along in a positive way. Particularly if that development enabled the reading and streaming of S-101 data, as an example. It is a valuable idea and similar to your idea about tightening up what we have and having test data sets available so people can bring those systems out and be sure that they work.

Q: On the weather side we rolled out and showed you what we are thinking. Primarily we are dealing with marine forecasting around the globe, marine services, program managers, and IHO. Do you see any flaws in what we are thinking? We have divided things because it was too big to take on all in one push. We did S-412 because that is our core mission and it breaks out in standalone the hazards. The emphasis right now is working on that. S-413 is combination pot of graphical and grids. Are there any comments for us?

A: I was initially confused by "conditions" versus "observations". Once I learned what they were it made sense, but it was not immediately intuitive.

Q: I have a clarification. Someone asked me "what about waves"? Do you mean wave heights? Is weather doing waves or is the IHO doing waves? Waves could also be critical for Precision Navigation.

A: Waves will be on our end [NWS]. There is also the matter of "dangerous seas" which was mentioned and should be defined.

Q: Does that give the full spectrum of waves or just average wave height? In the Port of Long Beach we found the full spectrum was needed.

A: If you are trying to anticipate the behavior of a vessel, it is the vessel response to the given wave fields. We have to work to figure out what the minimum is that we need to do to better depict wave conditions. Waves have very unique conditions as you are entering ports, especially in areas of currents.

Q: How are you envisioning the weather warnings to tie in to navigation warnings? Two data sets?

A: We are looking at the language of the weather warnings to be similar to the navigation warnings – after all it is the same customer. They are different but we are looking at the attributes and trying to not necessarily duplicate but find out where navigation is going.

A: Navigation warning categories are very good. Then we get to "physical phenomenon" but I want more categories than that for weather. Make sure you get all the categories you need and separate out the physical phenomena.

Additional "Live Polling" Comments and Questions

The following comment was posed via "live polling" for post-meeting consideration:

- Concise API documentation and code samples.

Topic Four: Prevision Navigation into the Future

The final topic was on Precision Navigation into the future. All workshop attendees engaged in open discussion and answered the following questions about NOAA's continued development of the Program, preferred methods of continued engagement between NOAA and its stakeholders and user communities and asked to provide an estimated timeline for Precision Navigation service integration as rough baseline for going forward.

External NOAA Recommendations and Insights

Attendees were asked to respond and discuss the following question:

"*What insights and recommendations do you have for NOAA as it embarks on developing its Precision Navigation Program, and/or what should NOAA be aware of from your industry/perspective?"*

Discussion Summary

Q: Now we know what Precision Navigation is, the name is going to cause headache and confusion. Precision Navigation as a name is a little misleading as it is really about data consolidation and integration. I suggest NOAA finds a name that really fits what we are all doing to avoid confusion. For example, "Marine Data", "Data Serve", "Data Hosting", or something similar. Some way to better describe what you all are trying to do – the word "navigation" throws me. Can the name be changed?

A: What led us to this name is when we looked at the data streams that under keel clearance systems needed to get to the level of prediction needed – few relied on the data we were providing. We found out in Long Beach we didn't have that data well organized so that companies could use it to determine if a ship could make passage or not. It was in that context that we came up with "Precision Navigation". I certainly appreciate the comment because it is one that we constantly come back to and even internally we deal with others who use "Precision Navigation" for other settings.

A: We appreciate the feedback but may not be able to change the name at this point because NOAA is now tied into it from a budget perspective. We will lose traction if the name changes, but I take your point, that is one reason we wanted to have this workshop so that you all would understand the Program fully. As we get further along in our product we will define it very clearly on our website. Right now if you do a search you will at least come across literature that clearly explains it.

Q: What is happening at the upcoming New Orleans public event?

A: NOAA is required to set up an advisory committee of 15 who become special government employees when they meet and we have public meetings. In New Orleans the meeting will be focused on the Mississippi river. There will be honored guests and a panel. A major focus will be Precision Navigation. Craig Winn will give a talk and we have invited all four pilot groups. Federal pilots have backed out but the others will be on the panel. Then a panel of other stakeholders in the maritime domain will be held. We will give them the same kind of overview we have given here to a variety of stakeholders that represent different pieces of the maritime industry. We will talk about issues on the river and in relation to our products and services. The public will attend and there will be able to participate in an open comment period. Afterward, federal advisory committee members write recommendation to the head of NOAA. Sometimes we can enact those, and other times it is based on other funding that is beyond our control.

Additional "Live Polling" Comments and Questions

The following comment was posed via "live polling" for post-meeting consideration:

- Abandon ISO 8211!

Preferred Methods of External NOAA Engagement

Attendees were asked to respond and discuss the following question:

"What are the best methods to continue to engage with organizations like yours on Precision Navigation services, progress, impact, and opportunities for improvement?"

Discussion Summary

Designated liaison: Having a designated person to talk with and stay current on developments with would be helpful.

Annual workshops: This workshop has been very helpful and productive. In an informal hand-raising poll, the majority of industry attendees indicated that they would participate in an annual workshop similar to this one. NOAA indicated its willingness to continue these workshops on an annual basis as well.

Formal and informal email updates: Contact information from all workshop attendees is now available (see page 53) and NOAA can continue to send out updates and information as the Program progresses. NOAA is also looking for volunteer beta testers, and attendees are encouraged to email Captain Liz Kretovic or John Kelley if they are interested in participating.

Broaden federal engagement: Broaden engagement with other federal agencies and private industry. There is another workshop being planned for this fall that will focus on an audience of federal partners and data providers. This initial workshop was focused on industry to ensure private sector engagement and support would be behind the Program, and it would seem that this has been validated by the participation and success of this workshop. Moving forward the circle will continue to widen.

Broaden private sector engagement: Broaden private sector engagement, particularly among mariners. Consider extend invitations or reaching out to the following organizations to raise awareness:

- American Pilot Association (APA)
- American Waterways Operators (AWO)
- International Organization of Master, Mates and Pilots (MM&P)
- Marine Engineers' Beneficial Association/Union (MEBA)
- Maritime Institute of Technology and Graduate Studies (MITAGS)
- Seafarers International Union (SIU)

Additional "Live Polling" Comments and Questions

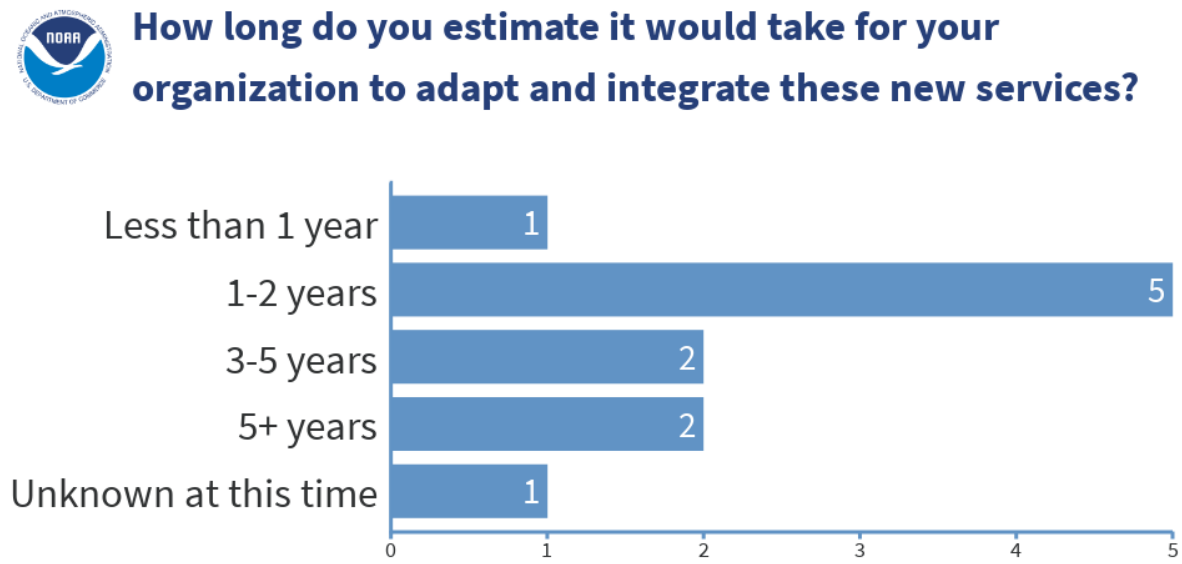
The following comments were posed via "live polling" for post-meeting consideration:

- Provide a developer forum on the website.
- Hold more Precision Navigation workshops.

Estimated Timeline for Precision Navigation Service Integration

Lastly, attendees were asked the following question: *"How long would it take for your organization to adapt and integrate these new services?"*

The question was posed to elicit a rough indication of expectations to aid in planning and understanding as the Program continues to be developed and rolled out. Responses were mixed, but most respondents envisioned integration taking between 1-2 years, and the majority (73%) envisioned integration occurring within 5-years. Granted, more information and continued dialogue will be required to develop a firmer grasp of delivery times, but the results at least indicate that new services will likely begin to be integrated within the first 1-2 years of rollout.



Closing Remarks

As the workshop came to a close, John Kelley offered summary remarks. He expressed gratitude to everyone who had participated in the workshop, from the NOAA presenters to the industry and academic partners that took time to participate and contribute their valued feedback. He also thanked those that helped support the design, logistics, and facilitation of the workshop at NOAA (Captain Liz Kretovic, Christine Burns, and Jason Greenlaw), UNH (Wendy Monroe and Renee Blinn), and Lynne Carbone & Associates (David Bidwell and Karen Gray). He emphasized that all this input and participation will help NOAA make Precision Navigation a better program, and that he looks forward to continued engagement, communications, and workshops in the years to come.

A complete account of all comments and workshop ratings may be found in *Appendix D: Session Evaluations* on page 55.

Next Steps

The following actions and agreements were reached during the workshop:

Description	Who	When
1. Hold a broader workshop focused on other NOAA and federal partners to continue to build understanding and support for Precision Navigation.	NOAA	Fall 2019
2. Plan annual Precision Navigation workshops with industry to keep the momentum and support up, elicit continued feedback, and help develop the Program.	NOAA and All Attendees	Summer 2020
3. Continue to engage informally with one another – ask questions, make suggestions, stay involved. Precision Navigation will be a success due to the continued engagement and support of NOAA's industry partners.	All Attendees	Any Time
4. Email Captain Liz Kretovic (Elizabeth.Kretovic@noaa.gov) or John Kelley (John.Kelley@noaa.gov) if you or your organization are willing to volunteer as beta testers.	All Attendees	Any Time

Appendix A: Topical Sort of All Breakout Group Responses by Question

Topic One: Non-Real-Time Precision Navigation Products (S-102 Gridded Bathymetry, S-57/S-101 High-Definition Charts)

**All [bracketed numbers] reflect the total vote tally the response received in its original breakout group.*

1. What obstacles and challenges do you face in utilizing our HD ENCs and gridded bathymetry?

File Size, Access Speed, and Bandwidth

Users have different data, information, bandwidth, and unique location-based requirements. Precision Navigation will need to provide solutions to each user profile and location (i.e. distance from shore) to ensure information is conveyed quickly and can be accessed easily with varying levels of bandwidth and resolution needs.

- Portrayal standard needs flexibility to meet various needs in different ports [20]
- Speed - How quickly can data reach the end user (less than 24 hrs.; depends on how dynamic the environment) [16]
- The challenge of delivering data: High resolution data will be very large so sending data around and working with large dataset may cause latency problems and local storage problems. This is helped by determining what resolution is needed for each application, thus allowing for data to be scaled. [10]
- Impact of file size and data density on processing (limited CPU/Memory resources on PPU) and bandwidth [5]
- User location specific API [4]
- Data volume/access - We need appropriately sized tiles to support dissemination so that we can access it by the user specific location. The tile data size should support wireless data dissemination. You need to be able to retrieve data for only the area you are interested in (wirelessly). [4]
- Potential bandwidth limitations [3]
- Data transmission - ship-shore [3]
- Access - tiles by region (instead of whole download)
- HD data - PRIMAR - data needs to go out to users fast. < 1 day
- Bandwidth

Data Accessibility and Dissemination

Data must be easily discoverable and accessible, and good documentation and code examples will help make this possible.

- The availability and the ease of finding data may be problematic. A centralized repository will aid in data retrieval. Outreach can be used to advertise the new data, describe it and teach where it can be found and how to use data and products. [9]
- Documentation and code examples to read and access data [7]
- Format available in open source library [5]
- Documentation - make it easy. [5]
- Update frequency [4]
- Others (Rec / tugs, tows) dissemination

Appendix A: Topical Sort of All Breakout Group Responses by Question

Visualization Needs

Visualization needs vary based on location and user profile, and displays will need to be flexible and customizable.

Overall displays need to be simplified – too much clutter onscreen can become distracting and deter users or limit effectiveness.

- Visualization of gridded bathymetry, i.e. how do you portray depths in other ways than just a color scale, as a gridded format does not have polygons or contours [16]
- Need for ability to display Go/No-Go zones based on total depth & ship characteristics/position [13]
- Understanding Challenges mariners face in different areas - what is the resolution needed for the navigation situation [5]
- Presentation of data - usability [2]
- Contours v. gridded bathymetry [2]
- Feedback from users/pilots 3D Bathymetry is too complicated [2]
- Scaling [1]
- Too many contours in HD ENC [1]
- Access to high resolution data [1]
- S52 display standard is outdated
- Simplified go/no-go - they don't need detailed contours

Uncertainty and Data Consistency

Understanding data uncertainty and striving for data consistency will be critically important. Users will need to understand how data decays over time, inconsistencies between different products, scales, and data sources all in a highly dynamic and ever changing environment.

- If NOAA is only providing data then individual manufacturers' portrayal may deviate significantly from standards. I.e., ECDIS standards, different use cases for different users. This could be challenging for users who need to switch between systems. [24]
- Uncertainty - Uncertainty value for all products should be delivered to 1 sigma. The uncertainty needs to be provided along with its confidence interval. How does the data decay with time? What's the expiration date on that value? [10]
- Comparing inconsistencies between different products at different scales [10]
- Determining the uncertainty of the dataset produced may cause problems. High resolution data creates the expectation of accuracy and dependencies on the visualization produced, however the dynamic environments may change rapidly making these data quickly obsolete. [8]
- Without near real-time access to the data, quality may degrade over time. Need the ability to communicate data quality/accuracy/age of data to increase confidence in product. [7]
- What is the challenge to the organization to combine newer single beam with older multibeam and non-authoritative data - how does the end user understand the differences? [6]
- ECDIS standards [1]

Building the Pipeline

The industry needs to continue to build the pipeline of future users, this necessitates a culture change, training to support transition, and technology changes.

- Major cultural change needed to fully adopt. [12]
- Hardware constraints / tech changes [6]
- Training gaps (Maritime Academy) [4]
- Generational "hiring." Cultural → takes time. Need vision. Could be a "reaction. [4]
- Address transition between ENC and HD ENC [4]
- We need a well identified data update regime. Robust process for updates. [3]

Topic Two: Real-Time Precision Navigation Products (S-111/S-104 Surface Currents/Water Levels & S-41X Marine Weather)

1. What NOAA data streams are you currently ingesting and how?

There is a wide range of NOAA data streams currently being ingested, including NDFD and other forecasts, PORTS, real-time weather and water observations, PROTIDE, ENCs and more. Given the broad range of data needs articulated by the collective breakout groups, there is great need and advantage in consolidating data within a single easily discoverable and accessible site.

NDFD and Other Forecasts

- Pilots (SE) want spot forecasts like Tampa, FL
- Weather
- Not using OFS in Jacksonville
- NDFD - National Digital Forecast Database
- NDFD Temp/Humidity Forecast - proxy for fog/visibility

PORTS®

- PORTS®
- PORTS® sensors
- PORTS® data via API
    - Tide
    - Current PORTS®
    - Visibility
    - Airgap
    - Salinity
    - Predictions

Real-Time Observations

- Real-time observations from CO-OPS
- Ingesting: CO-OPS API (Wind, wave spectra, bathymetry, forecasts, sea temp, tides, currents, water density, airgap?) Need: Lightweight, up-to-date, configurable data. *NOAA Need to do Gap analysis of data streams.
- Real-time obs of water levels.

Appendix A: Topical Sort of All Breakout Group Responses by Question

PROTIDE

- PROTIDE
    - Tides
    - Currents
    - Water levels
    - 2D use spectrum
- Tides and Currents/ Weather via 3rd party delivery

Currents

- Miami - currents - want to add current
- Currents

ENCs

- NOAA ENCs
- NOAA ENCs

Data Delivery

- How do you deliver dynamic data?
- Consolidated API (SPA documentation) in easy use format

Vertical Position

- The highest priority are the things that affect ship vertical position.
    - Water Levels
    - 2D Wave Spectra
    - Salinity

Mobile App

- NaAVIC - mobile app (recreational)
    - ENC
    - WMX service
    - Tide stations (poll data)
    - Water levels
    - Currents

S-57

- S-57

Salinity

- Would be to develop a specification on salinity

HF Radar

- HF radar

Bathy

- Bathy

Appendix A: Topical Sort of All Breakout Group Responses by Question

2. What are the most important variables to capture and visualize in real-time as you consider the future of Precision Navigation?

By frequency and vote count across all breakout groups, the most important variables to capture and visualize in real-time are depth, tide, water level, and waves. Beyond these core features, other notable variables with two or more mentions across all breakout groups are marine weather, use of robust APIs, customized portrayals, PORTS sensors, AIS, visibility, and wind.

Bathy, Depth, Tide, Level, and Waves

- Variables: Real time water level Ob's (6 min), currents (6 min), water density (6 min), wind/wave (30 min) [22]
- Currents [14]
- Water Levels [11]
- Accurate Depth (including bathymetry and water levels) [4]
- Waves [4]
- Wave spectra (30 min), Bathymetry (location dependent-push updates as soon as possible (Forecasts for both) [3]
- Not currently using bathy but using specified depth instead
- Tide aware bathymetry
- SEICHE

Marine Weather

- Weather - marine weather, marine forecasting. Want to be able to tap in automatically, each API different, so haven't been able to integrate quickly.
- Pilots in Tampa really like the spot forecasts
    - Miami would like to see more current information offshore - need an OFS or HF RADAR
- Pilots in Tampa really like the spot forecasts
    - Not using OFS in Jacksonville
    - Miami currents interpolated Pointed Forecast want to add current to ports
- HF radar

Robust and Consistent APIs

- Inconsistent APIs
- Consolidated API (with SPA documentation) in easy use format
    - TAB examples in the documentation
- API needed for National Weather Service [4]

Customized Portrayal

- Customized portrayal for different user communities
- How do you deliver dynamic data?
- Mariner and Surveying have slightly different R-T needs. Surveying wants to know about the pycnoclines so they can avoid the rapid change in salinity or temperature.

PORTS Sensors

- Air Gap needs improvement -- we need a better understanding of where Air Gap measurement applies across the bridge. Also ability to have a forecast. [4]
- Ports sensors

Visibility

- Visibility / fog important [4]
- Visibility

Wind

- Winds [2]
- Wind

Other Variables

- Salinity
- Ice
- Air Temperature
- Sound speed

AIS

- AIS / VTS [11]
- AIS

Vector Tiles

- Want vector tile service for ENC

Technology Developments

- Evolution of technology regarding data models

3. What obstacles and challenges do you anticipate in utilizing real-time products? For example, is there a minimum reliability/update time needed for real-time products to make a positive impact on your organization?

In order of frequency, the greatest obstacles and challenges to the utilization of real-time products are reliability in data and observation quality and availability, a user-friendly visual display and formats, appropriate update frequencies, dependable technology infrastructure, good documentation, proper training and use of data, and appropriate cyber security considerations.

Reliability

- Quality (Flag invalid data - QUARTOD) [16]
- Reliability/Redundancy [14]
- Reliability (uptime of instruments, storage of data, and data delivery) [13]
- Availability /Reliability [7]
- What is the reliability that we can expect? Clear set of SLA from NOAA. Status flag to check via API (follow up with Marco Timmer, PROTIDE). [5]
- Reliability is different for every product
- Ensuring consistency. Zoom level product level consistency
- Data quality control

Interoperability and Information Overload

- Clutter / Too much information [10]
- Influence of human and regulatory factors on acceptance, especially mitigating information overload and ensuring interoperability of multiple products. Utilize human factors design methods to mitigate information overload on navigators screen. [8]
- Data Volume [7]
- Visual interoperationality
- Scale

Update Frequency

- Data update frequency [5]
- Bandwidth [4]
- What's the turnaround time? (between model run & publish) [2]
- Update times / latency [1]

Technology Infrastructure

- Dependency on technology (Loss of skill, over-reliance on technology causing any technology problem to cause a problem with the fundamentals of navigation, loss of the ability to read paper charts - like my daughters' inability to find places without the turn-by-turn navigation on their phone) [6]
- Software bus [4]
- Redundancy of instruments [3]
- Underlying infrastructure [2]

Observations

- Scarcity of Observations [9]
- No downtime for observations
- Time stamps for observations

Portrayal and Formats

- Format of real-time data output [6]
- Original format of data - tiff can't be manipulated where a vector could [4]
- Context for portrayal (what are the conditions)

Data Use

- Translate input to decisions [2]
- Proper use of data
- Training

Documentation

- Well documented API that is robust and consistent across all data streams. (example code or Swagger is a good tool). The API structure should follow a standard. Open data API framework. [9]
- Documentation, communication, data owner [7]

Cybersecurity and Ease of Access

- Cybersecurity considerations - encryption and authentication
- Continued open & free access (without required authentication/security protocol)

Topic Three: Prevision Navigation Product Dissemination

1. What methods make the most sense for you to discover and access data?

The broad consensus is that there needs to be an API with metadata backbone and a single one-stop-shop site for data discovery and access. In terms of communications and notifications, the most prevalent methods are traditional mailing lists, social media, homepage messages, and online catalogs and subscriptions.

API

- API is the best method of searching for and accessing data (for accessing data) [20]
- API is the best method of searching for and accessing data (for navigation) [15]
- Discovery API
- API - Have the metadata discovery backbone embedded into the API
    - What products are available
    - Give me information about product X
    - Give data for e product x, location y, time z
- Primary API Discovery page (both human and machine readable [xml]) with geospatial representation of available data. Also include contact info for problems.
- Web services backed by standardized metadata

Appendix A: Topical Sort of All Breakout Group Responses by Question

Notifications and Announcements (Mailing, Social Media, Homepage)

- Mailing lists, blogs/social media, marine navigation website
- Mailing list / notifications
- Communication of format and protocol changes similar to what is done for models (Service change notice)
- Social media
- RSS feed
- Noaa.gov
- Cloud Notification Services

Online Catalog Services

- NOAA hosted online catalog of data links and repository [12]
- Geographic based subscription [12]
- Internet search [5]
- Subscription [4]
- OGC web catalogue services
- Online catalogs

Focused Access Points/Versions

- FTP/rcp/wget/http - with the hope this becomes obsolete [7]
- One Stop Shop. Single Page Architecture (SPA) and JSON XML REST.
- Limit other non-official versions
- Just ONE Of few methods

Map/GIS Interface

- Integrated multi-layer web GIS [10]
- NOAA to display data [2]
- Map interface

One-on-One/Direct Interaction

- Workshops/conferences [1]
- Outreach via navigation managers, etc.

Data Integration and Storage

- Data/software integration
- Data tank

XML, JSON, and Vector Tiles

- XML S-100, JSON and Vector Tiles.

Documentation

- Good documentation (SPA + left endex)

Understandable Name

- Consider renaming "PN" + ID a more understood domain name. (E.g., data serve, data consolidation)

Automated Machine to Machine

- Automated Machine to Machine [16]

2. What are your format requirements/restrictions to easily and reliably utilize Precision Navigation data?

The main format requirement to reliable Precision Navigation utilization is that users are able to customize the data that they see based on their bandwidth and resolution requirements. Higher resolution and large file sizes can be problematic, and end users should be able to select parameters as they need them.

Compatible and interoperable formats are also critical, with frequently cited formatting types being JSON and XML. S-100 compliance is also a key requirement. Furthermore, if Precision Navigation is to go real-time, it will need to be highly reliable and necessitate reconfiguration to ensure success.

User-Defined/Customizable Data (Bandwidth and Resolution)

- Customizable parameters (user may request the type and resolution of data requested) [9]
- File size limit by GSM or radio link [8]
- Support Multiple Versions [6]
- Do not overload data; adjust for use + purpose
- Have ability for end user to define data needs resolution
- Restriction: bandwidth
- Need to remember that there needs to be a stable internet connection
- Restrictions - data size, "cloud" limitations, interoperability
- Model data should be available at a variety of resolutions to support zoom levels from overview to model resolution
- S102 → 2 purposes: 1) navigation, 2) research. Provide different grids at different resolutions.

Formatting Types

- Open Formats /Supportive [10]
- Compatibility among datasets (persistent identifiers need to be compatible to assemble data together and link parts of data to parts of another dataset) [9]
- Format requirements (xml, csv, json) not as important as documentation! [17]
- JSON, CSV, XML [3]
- How to convert data format to data service [2]
- JSON\XML
- Vector Tile
- Machine Discoverable
- S57
- XML to GML
- Format requirements to utilize data

S-100 Compliance

- S-100 compliant [24]
- Data that conforms to S-100 framework [12]
- S100 when availability + documentation [1]
- Recommendation: Explore the possibilities of expanding the OGC geoserver library to support S100 dissemination requirements (S100, ENC)

Reliable Data Streaming

- Reliability: data quality metric (pass on quality flags). Most users poll for new real-time data every minute. [16]
- Data should be structured to support data streaming
- We need an easily accessible universal data model as a consistent way to support data streaming.

Incremental Updates

- Incremental ENC updates (001, 002), yes, but not catalog updates

Digital Signatures

- Digital Signature

3. How would you prefer to contact NOAA when there are problems with the data delivery and dissemination system?

There is a great deal of consensus on how people would prefer to contact NOAA in the event of problems. There should be:

- ***A 24x7 support line for real-time assistance in the form of phone, online chat, and email.***
- ***A highly visible contact instruction on the home page that includes simple forms for communicating and reporting problems.***
- ***An automatic confirmation of receipt upon issue submission; people should not be left to wonder if their message was received or how/if it will be acted upon.***
- ***Proactive announcements and notifications from NOAA when there is a known issue; this will alert users to issues and cut down on the volume of duplicate issue reporting from users.***
- ***Automated responses (AI, machine to machine, and bots) to increase speed and efficiency.***
- ***Tiered support based on the severity of the issue; response times and attention should be directed to top priorities before lower-level issues.***

Proactive Announcements and Confirmations

- Proactive announcements page with updates on outages [7]
- Dashboard systems status [7]
- Data dashboard [2]
- Proactive status when system is down or sensors are out.
- Cloud notification services subscription
- Ensure receipt of request. 24/7 support.
- Alert mechanism

Appendix A: Topical Sort of All Breakout Group Responses by Question

Help Desk/Support Line

- 24-7 High Quality Support (phone, chat, person) [24]
- Developers Help Desk - It needs a way to submit official tickets (JIRA/confluence) and an emergency CALL JOHN button [19]
- E-mail :([9]
- Phone number to reach human for non-emergency issues. [9]
- Open communications for continuous feedback [8]
- Phone [7]
- Email [4]
- Online chat [3]
- End user support line (to answer more basic questions) [2]
- Dedicated Liaison/contact/channel of communication
    - Phone
    - Email
    - website
- Email
- 24-hour support line
- Chat
- Help desk

Visible and Simple Contact/Reporting Forms on Website

- What is the plan for marinenavigation.noaa.gov PN support? [8]
- Easy form to submit a request and phone number.
- Highly visible contact info on front page + simple form.
- Make it easy to report a problem
- All this info should be on splash page

Tiered Support

- Ticketing system and creating User forums resulting in a useable FAQ [10]
- Routing mechanism
- Response time will vary depending on the severity of the issue
- Tech support filter

Automating Responses

- Machine to machine: end user system provides immediate feedback when error or data not received when expected. [21]
- AI directed searching tagging questions to results [10]
- Bots

Workshops

- User workshops

Appendix B: Individual Breakout Group Responses

Breakout Group Members

Breakout Group 1

- Adam Gibbons, NOAA - NOS/OCS/CSDL/CMMB
- Captain Rick Brennan, NOAA - NOS/OCS/HSD
- Christine Burns, NOAA - NOS/OCS
- Colin Ware, UNH/CCOM
- Edward Nikodem Kuwalek, IIC
- Marco Timmer, Protide
- Raphael Malyankar, Portolan
- Shawn Maddock, NOAA - NOS/CO-OPS

Breakout Group 2

- Captain Elizabeth Kretovik, NOAA - NOS/OCS
- Captain Ryan Scully, Crescent City Pilot
- Denise LaDue, USACE
- Erin Nagel, NOAA - NOS/OCS/CSDL/CMMB
- Julia Powell, NOAA - NOS/OCS/CSDL
- Kyle Ward, NOAA - NOS/OCS SE Nav Manager
- Svein Skjervik Skjaeveland, Primar
- Thomas Butkiewicz, UNH/CCOM
- *For Topic 3: Joe Sienkiewicz (Group 3) replaced Julia Powell*

Breakout Group 3

- Bob Daniels, NOAA - NWS/NCEP/OPC/OAB
- Captain Michael Bopp, Crescent City Pilot
- Drew Stevens, UNH/CCOM
- Jakob Poulsen, Trelleborg/Marimatech
- Jason Greenlaw, NOAA - NOS/OCS/CSDL/CMMB
- Joe Sienkiewicz, NOAA - NWS/NCEP/OPC/OAB
- John Kelley, NOAA - NOS/OCS/CSDL/CMMB
- Lucy Hick, NOAA - NOS/OCS/NSD
- Sarah Wolfskehl, NOAA - NOS/OCS/CSDL
- *For Topic 3: Julia Powell (Group 2) replaced Joe Sienkiewicz*

Breakout Group 4

- Hillary Fort, NOAA - NWS/NCEP/OPC/OAB
- Kim Munk Petersen, Trelleborg/Marimatech
- Noel Dyer, NOAA - NOS/OCS/MCD
- Peter Stone, NOAA - NOS/CO-OPS
- Ryan Heinz, SevenCs

Breakout Group 5

- Chris Hens, OMC
- Colleen Roche, NOAA - NOS/OCS NE Nav Manager
- Craig Winn, NOAA - NOS/OCS/MCD
- Ed Weaver, WR Systems
- Evan Martzial, QPS
- LCDR Benjamin LaCour, NOAA - NOS/IOOS
- Sam Debow, NOAA - NOS/OCS

Breakout Group 6

- Brianna Sullivan, UNH/CCOM
- Chris Paternostro, NOAA – NOS/CO-OPS
- Laurence David Benn, OMC
- Matt Close, WR Systems
- Matt Wilson, QPS
- Neil Weston, NOAA - NOS/OCS/CSDL

Appendix B: Individual Breakout Group Responses

Topic One: Non-Real-Time Precision Navigation Products (S-102 Gridded Bathymetry, S-57/S-101 High-Definition Charts)

1. What obstacles and challenges do you face in utilizing our HD ENCs and gridded bathymetry?

Breakout Group 1

- **Uncertainty - Uncertainty value for all products should be delivered to 1 sigma. The uncertainty needs to be provided along with its confidence interval. How does the data decay with time? What's the expiration date on that value? [10]**
- **Data volume/access - We need appropriately sized tiles to support dissemination so that we can access it by the user specific location. The tile data size should support wireless data dissemination. You need to be able to retrieve data for only the area you are interested in (wirelessly). [4]**
- **User location specific API [4]**
- We need a well identified data update regime. Robust process for updates. [3]
- Presentation of data - usability [2]
- Contours v. gridded bathymetry [2]
- Scaling [1]
- S52 display standard is outdated
- Simplified go/no-go - they don't need detailed contours
- Access - tiles by region (instead of whole download)

Breakout Group 2

- **Speed - How quickly can data reach the end user (less than 24 hrs.; depends on how dynamic the environment) [16]**
- **What is the challenge to the organization to combine newer single beam with older multibeam and non-authoritative data - how does the end user understand the differences [6]**
- **Understanding Challenges mariners face in different areas - what is the resolution needed for the navigation situation [5]**
- Others (Rec / tugs, tows) dissemination
- HD data - PRIMAR - data needs to go out to users fast. < 1 day

Breakout Group 3

- **Portrayal standard needs flexibility to meet various needs in different ports [20]**
- **Need for ability to display Go/No-Go zones based on total depth & ship characteristics/position [13]**
- **Impact of file size and data density on processing (limited CPU/Memory resources on PPU) and bandwidth [5]**
- Address transition between ENC and HD ENC [4]
- Update frequency [4]
- Feedback from users/pilots 3D Bathymetry is too complicated [2]
- Too many contours in HD ENC [1]
- Bandwidth

Breakout Group 4

- **Visualization of gridded bathymetry, i.e. how to you portray depths in other ways than just a color scale, as a gridded format does not have polygons or contours [16]**
- **Comparing inconsistencies between different products at different scales [10]**
- **Documentation and code examples to read and access data [7]**
- Format available in open source library [5]
- Potential bandwidth limitations [3]
- Access to high resolution data [1]

Breakout Group 5

- **If NOAA only providing data then Individual manufactures portrayal may deviate significantly from standards. i.e. ECDIS standards, different use cases for different users. This could be challenging for users who need to switch between systems. [24]**
- **Major cultural change needed to fully adopt. [12]**
- **Without near real-time access to the data, quality may degrade over time. Need the ability to communicate data quality/accuracy/age of data to increase confidence in product. [7]**
- Training gaps (Maritime Academy) [4]
- Data transmission - ship-shore [3]
- ECDIS standards [1]

Breakout Group 6

- **The challenge of delivering data: High resolution data will be very large so sending data around and working with large dataset may cause latency problems and local storage problems. This is helped by determining what resolution is needed for each application, thus allowing for data to be scaled. [10]**
- **The availability and the ease of finding data may be problematic. A centralized repository will aid in data retrieval. Outreach can be used to advertise the new data, describe it and teach where it can be found and how to use data and products. [9]**
- **Determining the uncertainty of the dataset produced may cause problems. High resolution data creates the expectation of accuracy and dependencies on the visualization produced, however the dynamic environments may change rapidly making these data quickly obsolete. [8]**
- Hardware constraints / tech changes [6]
- Documentation - make it easy. [5]
- Generational “hiring.” Cultural → takes time. Need vision. Could be a “reaction. [4]

Topic Two: Real-Time Precision Navigation Products (S-111/S-104 Surface Currents/Water Levels & S-41X Marine Weather)

1. What NOAA data streams are you currently ingesting and how?

Breakout Group 1

- The highest priority are the things that affect ship vertical position.
  - Water Levels
  - 2D Wave Spectra
  - Salinity
- NaAVIC - mobile app (recreational)
  - ENC
  - WMX service
  - Tide stations (poll data)
  - Water levels
  - Currents
- PROTIDE
  - Tides
  - Currents
  - Water levels
  - 2D use spectrum

Breakout Group 2

- S-57
- PORTS
- NDFD - National Digital Forecast Database
- Would to develop a specification on salinity
- Pilots (SE) want spot forecasts like Tampa, FL
- Not using OFS in Jacksonville
- Miami - currents - want to add current
- HF radar
- How do you deliver dynamic data?
- Ports sensors
- Consolidated API (SPA documentation) in easy use format

Breakout Group 3

- NOAA ENCs
- Real-time observations from CO-OPS
- NDFD Temp/Humidity Forecast - proxy for fog/visibility

Breakout Group 4

- NOAA ENCs
- Tides and Currents/ Weather via 3rd party delivery
- Ports data via API
    - Tide
    - Current
    - Visibility
    - Airgap
    - Salinity
    - Predictions

Breakout Group 5

- Ingesting: CO-OPS API (Wind, wave spectra, bathymetry, forecasts, sea temp, tides, currents, water density, airgap?) Need: Lightweight, up-to-date, configurable data. *NOAA Need to do Gap analysis of data streams.
- Real-time obs of water levels.

Breakout Group 6

- Bathy
- Currents
- Weather

2. What are the most important variables to capture and visualize in real-time as you consider the future of Precision Navigation?

Breakout Group 1

- Want vector tile service for ENC
- Inconsistent APIs
- Not currently using bathy but using specified depth instead
- Weather - marine weather, marine forecasting. Want to be able to tap in automatically, each API different, so haven't been able to integrate quickly.

Breakout Group 2

- Pilots in Tampa really like the spot forecasts
- Consolidated API (with SPA documentation) in easy use format
    - TAB examples in the documentation
- Not using OFS in Jacksonville
- Miami currents interpolated Pointed Forecast want to add current to ports
- HF radar
- How do you deliver dynamic data?
- Ports sensors

Breakout Group 3

- **Air Gap needs improvement -- we need a better understanding of where Air Gap measurement applies across the bridge. Also ability to have a forecast.[4]**
- **Accurate Depth (including bathymetry and water levels) [4]**
- **Visibility / fog important [4]**
- **API needed for National Weather Service [4]**
- Wind

Breakout Group 4

- Tide aware bathymetry
- AIS
- Evolution of technology regarding data models

Breakout Group 5

- **Variables: Real time water level Ob's (6 min), currents (6 min), water density (6 min), wind/wave (30 min) [22]**
- **Wave spectra (30 min), Bathymetry (location dependent-push updates as soon as possible (Forecasts for both) [3]**

Breakout Group 6

Mariner and Surveying have slightly different R-T needs. Surveying wants to know about the pycnoclines so they can avoid the rapid change in salinity or temperature.

- **Currents [14]**
- **Tie - AIS / VTS [11]**
- **Tie - Water Levels [11]**
- Waves [4]
- Winds [2]
- Salinity
- Visibility
- Ice
- Air Temperature
- SEICHE
- Sound speed

3. What obstacles and challenges do you anticipate in utilizing real-time products? For example, is there a minimum reliability/update time needed for real-time products to make a positive impact on your organization?

Breakout Group 1

- **Well documented API that is robust and consistent across all data streams. (example code or Swagger is a good tool). The API structure should follow a standard. Open data API framework. [9]**
- **Influence of human and regulatory factors on acceptance, especially mitigating information overload and ensuring interoperability of multiple products. Utilize human factors design methods to mitigate information overload on navigators screen. [8]**
- **What is the reliability that we can expect? Clear set of SLA from NOAA. Status flag to check via API (follow up with Marco Timmer, PROTIDE). [5]**
- Original format of data - tiff can't be manipulated where a vector could [4]
- What's the turnaround time? (between model run & publish) [2]
- Visual interoperationality
- Ensuring consistency. Zoom level product level consistency
- Context for portrayal (what are the conditions)

Breakout Group 2

- **Cybersecurity considerations - encryption and authentication**
- **Reliability is different for every product**

Breakout Group 3

- **No downtime for observations**
- **Continued open & free access (without required authentication/security protocol)**
- **Time stamps for observations**
    - ***Note -- update rates is parameter dependent**

Breakout Group 4

- **Clutter / Too much information [10]**
- **Scarcity of Observations [9]**
- **Availability /Reliability [7]**
- Data update frequency [5]
- Bandwidth [4]
- Training
- Scale

Breakout Group 5

- **Reliability/Redundancy [14]**
- **Quality (Flag invalid data - QUARTOD) [16]**
- **Documentation, communication, data owner [7]**
- **Data Volume [7]**

Breakout Group 6

- **Reliability (uptime of instruments, storage of data, and data delivery) [13]**
- **Format of real-time data output [6]**
- **Dependency on technology (Loss of skill, over-reliance on technology causing any technology problem to cause a problem with the fundamentals of navigation, loss of the ability to read paper charts - like my daughters' inability to find places without the turn-by-turn navigation on their phone) [6]**
- Software bus [4]
- Redundancy of instruments [3]
- Translate input to decisions [2]
- Underlying infrastructure [2]
- Update times / latency [1]
- Data quality control
- Proper use of data

Topic Three: Prevision Navigation Product Dissemination

1. What methods make the most sense for you to discover and access data?

Breakout Group 1

- **Web services backed by standardized metadata**
- **Map interface**
- **OGC web catalogue services**
- **Discovery API**

Breakout Group 2

- One Stop Shop. Single Page Architecture (SPA) and JSON XML REST.
- XML S-100, JSON and Vector Tiles.
- Limit other non official versions
- Just ONE Of few methods
- Good documentation (SPA + left endex)
- Consider renaming "PN" + ID a more understood domain name. (E.g., data serve, data consolidation)

Breakout Group 3

- API - Have the metadata discovery backbone embedded into the API
    a. What products are available
    b. Give me information about product X
    c. Give data for e product x, location y, time z
- Cloud Notification Services
- Outreach via navigation managers, etc.
- Mailing lists, blogs/social media, marine navigation website

Breakout Group 4

- **Automated Machine to Machine [16]**
- **Geographic based subscription [12]**
- **Integrated multi-layer web GIS [10]**
- Online catalogs
- Mailing list / notifications

Breakout Group 5

- **Primary API Discovery page (both human and machine readable [xml]) with geospatial representation of available data. Also include contact info for problems.**
- **Communication of format and protocol changes similar to what is done for models (Service change notice)**

Breakout Group 6

- **API is the best method of searching for and accessing data (for accessing data) [20]**
- **API is the best method of searching for and accessing data (for navigation) [15]**
- **NOAA hosted online catalog of data links and repository [12]**
- FTP/rcp/wget/http - with the hope this becomes obsolete [7]
- Internet search [5]
- Subscription [4]
- NOAA to display data [2]
- Workshops/conferences [1]
- Social media
- RSS feed
- Noaa.gov
- Data/software integration
- Data tank

2. What are your format requirements/restrictions to easily and reliably utilize Precision Navigation data?

Breakout Group 1

- Data should be structured to support data streaming
- We need an easily accessible universal data model as a consistent way to support data streaming.
- Model data should be available at a variety of resolutions to support zoom levels from overview to model resolution
- Recommendation: Explore the possibilities of expanding the OGC geoserver library to support S100 dissemination requirements (S100, ENC)

Appendix B: Individual Breakout Group Responses

Breakout Group 2

- JSON\XML
- Vector Tile
- Machine Discoverable
- S102 → 2 purposes: 1) navigation, 2) research. Provide different grids at different resolutions.
- Restriction: bandwidth
- Do not overload data; adjust for use + purpose
- Have ability for end user to define data needs resolution

Breakout Group 3

- **Need to remember that there needs to be a stable internet connection**

Breakout Group 4

- **S-100 compliant [24]**
- **Open Formats /Supportive [10]**
- **Support Multiple Versions [6]**
- How to convert data format to data service [2]
- S57
- XML to GML

Breakout Group 5

- **Format requirements (xml, csv, json) not as important as documentation! [17]**
- **Reliability: data quality metric (pass on quality flags). Most users poll for new real-time data every minute. [16]**
- **File size limit by GSM or radio link [8]**
- S100 when availability + documentation [1]
- Incremental ENC updates (001, 002), yes, but not catalog updates

Breakout Group 6

- **Data that conforms to S-100 framework [12]**
- **Customizable parameters (user may request the type and resolution of data requested) [9]**
- **Compatibility among datasets (persistent identifiers need to be compatible to assemble data together and link parts of data to parts of another dataset) [9]**
- JSON, CSV, XML [3]
- Digital Signature
- Format requirements to utilize data
- Restrictions - data size, “cloud” limitations, interoperability

3. How would you prefer to contact NOAA when there are problems with the data delivery and dissemination system?

Breakout Group 1

- **Developers Help Desk - It needs a way to submit official tickets (JIRA/confluence) and an emergency CALL JOHN button [19]**
- **Proactive announcements page with updates on outages [7]**
- **End user support line (to answer more basic questions) [2]**
- Routing mechanism

Breakout Group 2

- Ensure receipt of request. 24/7 support.
- Proactive status when system is down or sensors are out.
- Easy form to submit a request and phone number.
- Highly visible contact info on front page + simple form.

Breakout Group 3

- Dedicated Liaison/contact/channel of communication
    - Phone
    - Email
    - website
- Response time will vary depending on the severity of the issue
- Cloud notification services subscription
- Make it easy to report a problem

Breakout Group 4

- **24-7 High Quality Support (phone, chat, person) [24]**
- **Open communications for continuous feedback [8]**
- **Dashboard systems status [7]**
- Online chat [3]
- Email
- Tech support filter
- 24-hour support line

Breakout Group 5

- **Machine to machine: end user system provides immediate feedback when error or data not received when expected. [21]**
- **Phone number to reach human for non-emergency issues. [9]**
- **What is the plan for marinenavigation.noaa.gov PN support? [8]**
- Email [4]
- All this info should be on splash page

Breakout Group 6

- Ticketing system and creating User forums resulting in a useable FAQ [10]
- AI directed searching tagging questions to results [10]
- E-mail :([9]
- Phone [7]
- Data dashboard [2]
- Chat
- Help desk
- Alert mechanism
- Bots
- User workshops

Appendix C: Workshop Attendees and Contact Information

NOAA Affiliates		
Name	**Organization**	**Email Address**
Adam Gibbons	NOS/OCS/CSDL/CMMB	adam.m.gibbons@noaa.gov
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Appendix C: Workshop Attendees and Contact Information

Stakeholder and Community Representatives		
Name	**Organization**	**Email Address**
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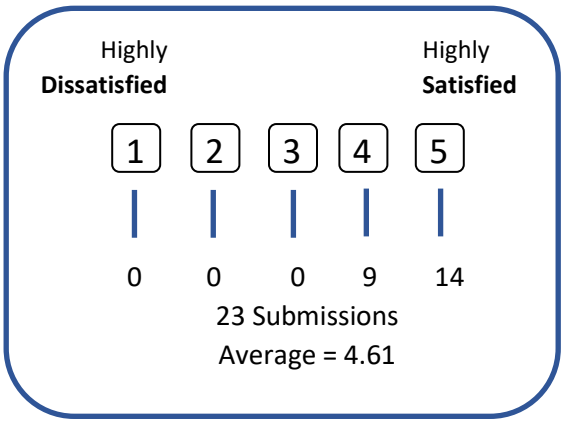
Appendix D: Session Evaluations

Please note that LCA has documented all submissions exactly as written.

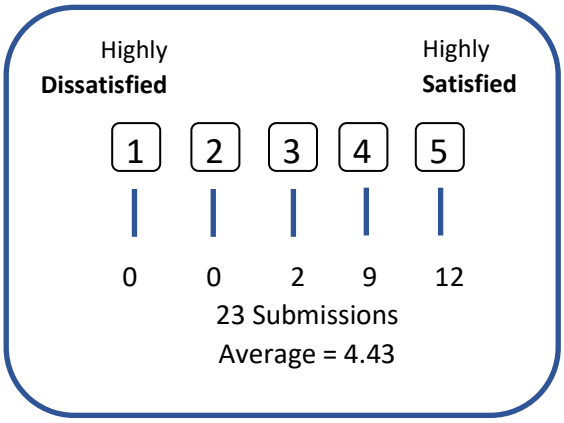
1. Overall, my rating of the meeting is:

- Very good.
- Very useful, informative meeting.
- Great to see the site and meet the people.
- Very good workshop. Hope good valuable information came from the group interaction.



2. My rating of the group interaction and our abilities to meet our desired objectives is:

- Great method for idea sharing.
- Some prodding from facilitator was misplaced and inappropriate. Went against goal of discussion.
- More clarity in questions, examples, and guidance.
- Probably could have handled a few more questions too.
- A lot of the breakout group responses were just a repeat of the talks before.



3. The part of the meeting I found most productive was:

- Meeting with the members of industry to get their wishes and requirements.
- Discussions during the breakout groups were quite educational.
- Breakouts.
- Group interactions.
- Group interaction following the briefings.
- Group discussion focused on specific areas (i.e., follow up to breakout groups).
- The breakout sessions & topic presentations on Day 2.
- Presentations about S100 (S100 & S102, in particular). This was information I'd long awaited (to hear how NOAA is moving forward with it).
- Learning NOAA's definition of PN.
- The stickers and voting.
- Hard to pick one aspect. The breakout sessions were very helpful as well as the discussions they inspired.
- Topic 3.
- Information from NOAA about plans.

- Breakout sessions.
- Breakouts.
- Group discussion.
- The breakout groups were very successful and insightful.
- Breakout sessions and following discussions.
- The networking with the NOAA experts on various topics.
- Group sessions were superb!
- Breakout sessions.
- Folks seem to know what PN is now.
- Breakout sessions.
- Q&As.

4. My biggest disappointment was:

- Realizing that there is much, much more work to do and appreciating the scope.
- Lack of participation by towing industry.
- Were none.
- More proof-of-concept evidence (but I understand it's early).
- I wish I could have heard more from industry.
- Nothing ☺.
- Would have liked to see a better balance of industry (less Fed).
- I'd love to see shorter timelines on delivery, but understand there are limitations.
- None.
- None.
- N/A.
- N/A.
- N/A.

5. My suggestions for future meetings are:

- Annually.
- Broader engagement with end user mariners.
- Keep up the good work!
- More towing industry involvement.
- I think you're doing just fine and no suggestions at this time.
- Announce "please hold questions until the end." It throws off the presenters' time schedule. In the breakout groups one facilitator was quite pushy with the amount of ideas and it wasn't really helpful.
- As things evolve, get more into details before breakout groups.
- More pilots.
- Better way to divide the teams.
- Good to have Kristos from UNH involved.
- More time to meet with people one-on-one.
- Similar format.
- Voting during breakout sessions was unnecessary.